

## Allelopathic potential of *Imperata cylindrica* on the growth and germination of *Zea Mays*

### ABSTRACT

Allelopathy is regarded as any process whereby secondary metabolites produced by plants influence the growth and development of agricultural and biological systems performing positive and negative effects. *Imperata cylindrica* is one of the top ten worst weeds and is listed among the world's top 100 worst invasive alien species. To assess the allelopathic potential of *Imperata cylindrica* on the germination and growth of *Zea mays*, *Zea mays* was treated with different concentrations of aqueous extract of *Imperata cylindrica*. The treatment was laid out in completely randomized designs with five treatments and 3 replications. Results indicated that the highest germination percentage was recorded from control whereas the lowest was at 20% concentration level. There was no significant difference in seed germination, root length, shoot length, seedling length, and vigor index between the treatments ( $P > 0.05$ ) when compared to the control. Crop residues of *Imperata cylindrica* could be spread on wastelands, resulting in the leaching of allelochemicals that would reduce the seed germination and consequently the population of weeds.

Keywords: allelochemicals ; *imperata cylindrica*; Maize; seed germination;

### INTRODUCTION

"Weeds are a major threat to crop production in many cropping systems. Aggressive weed competition reduces crop yield significantly and adds further cost to crop production owing to their management. Yield losses in crops due to weeds depends on several factors such as type of weed, crop type, time of emergence, weed density" (Chauhan *et al.*, 2020). "It has been observed that weeds may cause a reduction up to 25-30% in the yield of wheat" (Chaudhary *et al.*, 2008; Marwat *et al.*, 2008), 35-40% reduction in rice yield (Oreke and Dehne, 2004), 35-80% reduction in maize (Dangwal *et al.*, 2010) and 20-40% reduction in sugarcane yield (Khan *et al.*, 2004). "Among US crops, soybean and corn suffer the highest production loss because of weeds. Weed interference caused an average of 50% yield loss in corn in the USA and Canada across 2007-2013" (Soltani *et al.*, 2017. Soltani *et al.*, 2016). "Weeds can decrease the growth and yield of crops by interfering with different metabolic processes" (Hajizadeh and Mirshekari, 2011). The interference of weeds with crops may be the consequence of competition and/or allelopathy.

The term allelopathy is derived from a Greek word 'Allelon' means to 'each other' and 'Panthos' means 'to suffer' means injurious and harmful effect of one organism upon others. The term 'allelopathy' was first used in 1937 by Austrian scientist Hans Molich (Willis 2010). Allelopathy involves the chemical interaction among different plants, plants and different organisms (Cheng & Cheng, 2015). "Allelopathy refers to the direct or indirect effect of plants upon neighboring plants or their associated microflora or microfauna by the production of allelochemicals that interfere with the growth of the plant" (IAS, 2018). "The ability of various plant species to induce allelopathic impacts on plants in their surroundings has

been documented since ancient times. The most primitive writings on allelopathy are accredited to the Theophrastus (300 BC) who detected the detrimental effect of cabbage over the growth of a vine and proposed that such effects were occurred by odors from cabbage plants" (Willis, 1985).

"Allelochemicals are secondary metabolites which are liberated from plants and affect the germination and growth of recipient plants" (Kruse *et al.*, 2000; Asaduzzaman *et al.*, 2010). "Allelochemicals are released through volatilization, root exudation, residues decomposition and leaching from leaf litter, and they act upon by various modes of action. These type of allelochemicals are harmful as well as has beneficial effect on other plants in both direction" (Latiffet *et al.*, 2017 and Einhellig, 2018). "Previously, a release of allelochemicals by root exudation was considered marginal, however, nowadays, it is believed to be more important because 5-21% of fixed carbon could be excreted by roots" (Weston *et al.*, 2012). "Allelochemicals are very diverse and therefore it's difficult to establish a general action model; since it depends on the compound type, the receiving plants and how it acts. Allelochemicals can act at internal level and external level. Talking about the internal level, there is a large number of physiological parameters that can be affected. They have action on the cellular membrane, disrupt the activity of different enzymes or structural proteins or alter hormonal balance. They can also inhibit or reduce cellular respiration and chlorophyll synthesis, leading to a reduction in vitality, growth and overall development of the plant. These substances can also reduce seed germination or seedling development, or affect cell division, pollen germination", etc. (Ferguson *et al.*, 2013).

"At external level, the allelochemicals may be related to the release or limitation of nutrients that are found in the soil. Others act on microorganisms leading to a perturbation on the symbiotic relationships they establish" (Aguilela and Puch, 2004).

"Seed germination and plant growth is interrupted by the disturbance of a variety of physiological functions occurring within plant bodies. The plant functions of prime importance which are affected by allelochemicals include respiration, photosynthesis, cell division and enlargement, metabolic activities, protein synthesis and enzyme actions" (Lin *et al.*, 2004)

"One dominant weed in Ebonyi state is *Imperatocylindrica*. Decomposing residues of this weed are commonly left on the soil surface as mulches. However, it is known that plant residues of crops, weeds or natural vegetations left on, and in the soil, release assorted chemical compounds into the soil during decomposition. The chemical compound interferes with the growth of other plants and often adversely affect the yields of crop plants through the process of allelopathy. The allelochemicals are released on the environment by plant but, they are not directly aimed to the action site, thus it is a private mechanism. To be effective, allelopathic interaction needs that these substances are distributed along the ground or the air and that they reach the other plant. One of the most commonly grown edible seeds in this area are *Zea mays* (maize)". [27] This study was carried out to evaluate the allelopathic potential of *imperatocylindrica* on the germination of maize.

## OBJECTIVES

- To ascertain the effect of aqueous extract of *imperatocylindrica* on the germination of *Zea mays*
- To ascertain the effect aqueous extract of *Imperatocylindrica* on the plumule growth of *Zeamays*
- To ascertain the effect of aqueous extract of *imperatocylindrica* on the radicle growth of *Zeamays*



## MATERIALS AND METHODS

### 2.1 Study Area

The experiment was conducted at the laboratory of Applied Biology Department, Ebonyi state university abakaliki, Nigeria located on latitude 6° 22'26''N and longitude 8° 6'6''E of the Greenwich meridian.

### 2.2 Experimental design and layout

A completely randomized design was used with 5 treatment and 3 replications as follows:

Treatment	Variety	Replicates
Distilled water	1	3
20% (w/v-1) plant extract	1	3
15% (w/v-1) plant extract	1	3
10% (w/v-1) plant extract	1	3
5% (w/v-1) plant extract	1	3

### 2.3 Experimental Procedure

*Imperata cylindrica* was collected from crop fields and brought to laboratory. It was authenticated at the herbarium of the department of applied biology. The plant material was rinsed in clean water. The fresh leaves were cut into small pieces and pounded it using mortar and pestle. A 200g of the ground sample was measured and soaked in 2000ml distill water in a plastic bucket, and shaken regularly for 7 days, producing a 20% (w/v-1) aqueous extract. The aqueous extract of the weed sample was filtered and the concentrated aqueous extract collected in a beaker and stored. Some quantity of the 20% (w/v-1) extract were diluted to 15, 10 and 5% with distilled water.

The seeds of test crop (*zea mays* var Oba Super 4.) were treated with different concentrations of the aqueous extract. Ten seeds were placed equidistantly in 8cm diameter Petri plates fitted with two layers of filter paper. 5ml of 5, 10, 15 and 20% aqueous extract of *imperata cylindrica* were added into the petri plates as per treatment using syringe and needle daily. Sterilized water was used as control. The treatments were replicated three times in complete randomized design. The criterion for measuring germination is embryo protrusion, and this was evaluated every 12 hours during the first seven days of the experiment (that is seeds were considered as germinated upon emergence of radical).

### 2.4 DATA COLLECTION

The number of seeds germinated was counted on 1, 2, 3, 4, 5, 6 and 7 days after sowing (DAS) and seedling growth was measured at 7 DAS. The various growth parameters were evaluated as follows:

- i. **Germination percentage:** The formular given by Rehman et al. (1998) was used to estimate germination percentage. Germination % =  $\frac{\text{no of seeds germinated}}{\text{total no of seeds}} \times 100$
- ii. **Root and shoot length:** length of root and shoot of seedlings was calculated using the standard centimeter scale.

- iii. **Vigor index:** the formula suggested by Abdul-Baki and Anderson (1973) was used to calculate vigor index. Vigor index = Germination % x (root length + shoot length) on % x (root length + shoot length) in cm ).
- iv. **Mean germination time (MGT):** mean germination time was calculated by the formula given by Ellis and Roberts (1981). 
$$MGT = \frac{n_1 \times d_1 + n_2 \times d_2 + n_3 \times d_3 + \dots}{\text{total number of days}}$$

Where, n= number of germinated seed

d= numbers of days

- v. **Mean daily germination (MDG):** Mean daily germination was calculated by the following formula given by Czabator (1962). 
$$MDG = \frac{\text{total number of germinated seeds}}{\text{total number of days}}$$
- vi. **The phytotoxicity (%):** The phytotoxicity was calculated using the formula given by Chiou and Muller. (1972). 
$$\text{Phytotoxicity (\%)} = \frac{\text{length of control} - \text{length of treated}}{\text{length of control}} \times 100$$
- vii. **The extract tolerance index (ETI):** This was calculated using the formula determined by Turner & Marshall (1972). 
$$\text{ETI} = \frac{\text{mean length of the longest root and shoot in aqueous extract}}{\text{mean length of the longest root and shoot in the control}}$$

## 2.5 Statistical Analysis

Data on seed germination, shoot length, root length were analyzed using one-way analysis of variance (ANOVA)

**Table 1: Effect of different concentration of *Imperata cylindrica* on seed germination, root length, shoot length, seedling length and seedling vigor index of *Zea mays***

Mean in the same column with same letters are not significant while the ones with different letters are significant

Treatment	Seed germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Seedling vigor index
Control	100.00±0.00	9.54±0.82 <sup>a</sup>	8.66±0.38 <sup>a</sup>	18.04±1.67 <sup>a</sup>	17.6667±158.74 <sup>b</sup>
5%	90.00±5.77	9.38±0.88 <sup>a</sup>	7.99±0.82 <sup>a</sup>	17.55±1.58 <sup>a</sup>	1623.60±150.90 <sup>b</sup>
10%	80.00±5.77	9.23±1.00 <sup>a</sup>	7.07±0.80 <sup>a</sup>	16.31±1.73 <sup>a</sup>	1305.06±138.84 <sup>b</sup>
15%	76.66±3.33	8.75±1.12 <sup>a</sup>	6.68±0.87 <sup>a</sup>	15.77±1.97 <sup>a</sup>	1209.81±151.53 <sup>b</sup>
20%	76.66±8.81	8.26±0.91 <sup>a</sup>	6.11±0.90 <sup>a</sup>	13.51±1.74 <sup>a</sup>	1036.21±133.77 <sup>b</sup>

## RESULTS and DISCUSSION

### 3.1. Germination percentage

"Aqueous extract of *imperatacylindrica* exhibited allelopathic effects on maize. The effect of *imperatacylindrica* extract on crop showed that the concentration affected the germination percentage of the crop" (Lin *et al.*, 2004). As the data in table 1 indicated that the highest germination percentage was recorded from control while 15% and 20% concentration of the aqueous extract had similar germination percentage. The mean seed germination percentage of *zea mays* under different concentrations of aqueous extract of *imperatacylindrica* are given in table 1. There was no significant difference among the treatments  $P>0.05$ . As the concentration of the extract increased, the germination percentage decreased. It could be as a result of allelochemicals in the leaf extract which prevented embryo growth and development.

### 3.2. Shoot length

Different concentrations of aqueous extract of *imperatacylindrica* on the shoot length of *zea mays* are given in Table 1. There was no significant difference in shoot length between treatments ( $P>0.05$ ) when compared to the control. The data showed that the shortest shoot length was recorded in 20% concentration whereas the longest was observed from control. The difference in the activity of *imperatacylindrica* extract prepared from different fractions in suppressing germination of *zea mays* can be attributed to quantitative and qualitative differences in allelochemicals present in these extracts.

### 3.3. Root length

Different extract of *imperatacylindrica* at higher concentration forced a significant suppression in root length. Root length of the crop decreased by an increase in the concentration of *imperatacylindrica* as given in Table 1. Root length was lowest at 20% concentration whilst the highest root length was recorded in the control.

### 3.4. Seedling length

Seedling length was shortest at 20% concentration whilst the highest seedling length was recorded in control as shown on table 1. More inhibition by application of higher extract concentration may be due to the presence of a greater fraction of allelochemicals in concentrated extracts.

### 3.5. Seedling vigor index

Seedling vigor index significantly decreased when compared to control (Table 1). As the concentration of extract increased the vigor index decreased. The lowest vigor index was recorded at 20% concentration while the highest was recorded from control.

### 3.6. Mean Germination time

The mean germination time of *zea mays* under different concentration of aqueous extract of *imperatacylindrica* are given in (Table 2). 5% and 10% concentrations had similar mean germination times. The highest mean germination time was recorded in 15%

### 3.7. Germination index

The highest germination index was recorded in the control (Table 2). 15% and 20% concentration had similar germination index. There was no significant different among treatments.

### **3.8. Mean daily germination**

The highest mean daily germination was recorded in 20% concentration (table 2). 5% and 10% concentrations had similar mean daily germination.

### **3.9. Relative elongation rate of shoot and root**

The highest relative elongation rate of shoot and root was recorded in control whilst 20% concentration recorded the lowest relative elongation rate of shoot and root (table 2).

### **3.10. Phytotoxicity**

Phytotoxicity in maize seedlings at different concentration of aqueous extracts was found to be significantly different. Phytotoxicity increased with increase in the concentration of aqueous extract. The highest phytotoxicity was recorded in 20% concentration (13.4) whereas control recorded (0) as shown on Table 2.

### **3.11. Inhibition percentage**

Inhibition potentials of the shoot and root at their 20% concentrations were 29.45 and 13.45% for maize seed germination over control respectively. The lowest inhibition in seed germination was found for the 5% concentration over control (table 2). It reveals that as the dose increased the inhibition also increased which shows that the weed extract has inhibitory effect on seed germination of maize. Ahmed *et al*(2007) "applied extracts of *C. odorata* on receptor crops and observed that the inhibitory effect was proportional to the concentrations of the extracts and higher concentration had the stronger inhibitory effect".

### **3.12. Extract tolerance index**

"Tolerance index significantly reduced with increasing *imperata cylindrica* concentration when compared to control. Effect of different extract level of *I. cylindrica* concentration significantly affected the tolerance index of maize seedling. The highest tolerance index (30.9%) was recorded from control whereas, the lowest (1.04%) was recorded from 20% extract concentration. This is in accordance with the work Tahseen", *et al* (2015)



Control	1.00	10.71	3.42	100	100	0	30.9	0	0	0
5	0.9	10.42	3.28	92.2	98.3	1.67	1.12	7.67	1.71	10
10	0.8	10.42	3.28	81.6	96.7	3.24	0.98	18.3	3.22	20
15	0.0007	14.4	4.28	77.1	91.7	8.28	1.15	22.87	8.24	23.33
20	0.0007	12.71	3.85	70.5	86.5	13.4	1.04	29.45	13.45	23.33

## CONCLUSION AND RECOMMENDATION

### 4.1 CONCLUSION

From this laboratory experiment, it was revealed that the control treatment had maximum germination percentage and 20% treatment had the minimum. Extract of *imperatacylindrica* at 20% strongly reduced root length, shoot length, seedling length of the maize. Results also show that 20% aqueous extract had the highest inhibitory percentage and a lower tolerance index and vigor index. Different concentration of aqueous of *imperatacylindrica* significantly inhibited the growth and germination of maize and this inhibition is varied with the concentration of the extracts. *Imperatacylindrica* extracts showed inhibitory effect on shoot and root length but exerted more inhibitory effects on the shoot than on the root tested (table 2). Crop residues could be spread on wastelands, resulting in the leaching of allelochemicals that would reduce the seed germination and consequently the population of weeds.

### 4.2 RECOMMENDATION

Further studies are required to identify and isolate the most effective allelochemicals from *imperatacylindrica* and develop natural-product based herbicides to curb weeds.

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