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Allelopathic Effects Of *Juglans nigra* On Wheat And Rice

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ABSTRACT
Due to increased economic demands for the tree plant *Juglans nigra*, especially in the Niger Delta regions of Nigeria, farmers have developed a malpractice of inter-planting *Juglans nigra* in their crop farms, especially their cereal farms. Being a plant that has been notoriously reported as an allelopathic plant, studies were conducted to check and compare the allelopathic effect of *J. nigra* on the growth (plant height [HOP] and number of leaves [NOL]) of some of the world's most cultivated cereals - *Triticum aestivum* and *Oryza sativa*. Following a completely randomized design, the two plants were subjected to different concentrations (0%, 25%, 50%, 75%, and 100%) of the aqueous extract of *J. nigra* for a period of 8 weeks within which the parameters were measured biweekly. Results from the studies showed that, as the concentration of extract increased, the HOP and NOL of *T. aestivum* decreased while it increased the HOP and NOL of *O. sativa*. Using the Ochekwu Comparative Treatment Average (OCTA) Trend, it was established that, over the 8 weeks period of study, the HOP and NOL of *O. sativa* followed a positive trend while the HOP and NOL of *T. aestivum* followed a negative trend with increasing concentration of treatments, as compared with their respective control treatments. This finding goes a long way to suggest that while the allelochemical of *J. nigra* is potentially herbicidal to *T. aestivum*, it may have bio-fertilizer potentials in a rice farm. This allelopathic phenomenon of bilateral influence is not yet fully understood, but it may be traceable to certain physiological disparities between the two plants, despite being from the same family.
Keywords: Allelopathy; *Juglans nigra*; *Tritichum aestivum*; *Oryza sativa*; OCTA Trend.

INTRODUCTION
Wheat (*Tritichum* aestivum) and Rice (*Oryza sativa*), both cereals of the Poaceae family, are the top most consumed staples in Nigeria. These two are very much consumed in Nigeria and other African nations as the major staple for their seeds and cereal grain which is a worldwide staple food.
Many species make up the genus *Tritichum*, but the most widely cultivated is the common wheat, *Tritichum aestivum*. Wheat is reportedly grown on more land area than any other crop in the world. Nutritionally, wheat has been reported to provide the basic and essential amino acids and serve as a source of dietary fiber. Raw wheat can be ground into Semolina (edible flour) and can also be used in making malt. Wheat accounts for at least one-fifth of man's calorie intake (Ohiagu *et al*., 1987).
Rice (*Oryza sativa*), as a cereal grain, is the most widely consumed staple food for a large part of the world's human population. It is the agricultural commodity with the third-highest worldwide production, aside sugarcane and maize. Since a sizeable portion of the sugarcane and maize are used for other purposes other than human consumption, rice is the most important grain with regard to human nutrition and caloric intake; providing more than one-fifth of the calories consumed worldwide by humans. Mohammed *et al*. (2019) has shown that rice has consumption per capita of 32kg in Nigeria; and this indicates a 4.75 increase in the last decade. The importance of rice to the Nigerian consumers cannot be over-emphasized due to the various utilities it serves to the national economy, and also in the eradication of starvation and threats due to political uncertainty thus resulting to its general acceptance and increased consumption (Seck *et al*., 2012; Oludare, 2014).
Bano *et al*., (2012) described allelopathy as the direct or indirect influence of a chemical released from one living plant on the development and growth of another. Allelopathy, therefore, occurs when living

organisms produce bioactive compounds which enter the environment and produce direct or indirect effects on the growth and development of the same or other species (Seigler, 1996). Taiwo and Makinde (2005) have also described allelopathy as the inhibitory or stimulatory effect of a plant (donor) on another plant (recipient) through the release of allelochemicals. Allelopathy has been studied following several methods (Ochekwu and Udensi, 2015)

Allelopathy, the positive or negative chemical effect(s) a plant has on the growth parameters of another plant, has been a major problem menacing the cereals, especially wheat and sorghum (Muhammad *et al*., 2009; Musiyimi *et al*., 2017). One plant species that is established as a major allelopathic plant species and has been repeatedly reported to have notorious allelopathic potentials is the *Juglans nigra*. Jose and Gillespie (1998) reported the allelopathic effect of Juglone, the allelochemical of *J. nigra* on the growth of *Zea mays* and *Glycine max*. Other reports have been made on Cucumber (Kocacaliskan et al., 2009), Strawberry (Ercisli *et al*., 2005) and even on the seed germination of wheat (Bajalan *et al*., 2013).

Juglans nigra, the eastern black walnut, is a species of deciduous tree in the walnut family, Juglandaceae. Black walnut is an important economic tree, as it has commercial advantages of being straight-grained, deep-brown color and can be easily worked; and it is also regarded as a durable hardwood in Nigeria. The walnut fruits are harvested for their distinctive and desirable taste. Thus, black walnut is cultivated for both lumber and walnuts simultaneously.

Economic pressure, especially in the developing countries, has made many farmers attempt mix-cropping *J. nigra* with cereals in their farms. This malpractice therefore justifies this study to investigate the growth implications of such mixed cropping on the growth parameters of the widely consumed staples – *Tririchum aestivum* and *Oryza sativa*.

MATERIALS AND METHODS

Experimental Site

The potted experiment was conducted at the Center for Ecological Studies in the Department of Plant Science and Biotechnology, University of Port-Harcourt, Rivers state, Nigeria. It is on geographical coordinates: latitude 4° 52'N and 4° 55'N Longitudes 6° 54'E and 6° 56'E in Obio/Akpor Local Government Area(LGA) Rivers State. It is situated in the Niger Delta wetland of Southern Nigeria. The climatic weather condition of the area is characterized by tropical monsoon climate with mean annual temperature of 25°C to 28°C and annual rainfall of over 3000mm. The relative humidity is very high with an annual mean of 85% while the soil is usually sandy or sandy loam underlain by a layer of impervious pan.

Sources of plant materials

The seeds of the test crops (*Triticum aestivum* and *Oryza sativa*) were obtained from the Department of Agriculture of the University of Port-Harcourt. The leaves and stem of *Juglans nigra* were collected from Egbeke in Etche Local Government Area, Rivers State, and identified by a taxonomist from the department of Plant Science and Biotechnology of the University of Port-Harcourt.

Viability test on seeds

Viability test was carried to ensure the seeds were viable. Ten seeds from each of the test seeds (*Triticum aestivum* and *Oryza sativa*) were plated in Petri dishes lined with the Whatman No. 1 filter paper and kept for 7 days with 10ml of distilled water every 3 days.

8 seeds out of the ten seeds of *Oryza sativa* sprouted (plumule and radicle) showing 80% viability, while 10 seeds out of the ten seeds of *Triticum aestivum* sprouted showing 100% viability, thus showing that the seeds are good enough for planting as against <70% viability which would have indicated that the seeds may not be viable.

Preparation of stock solution of allelopathic leaves extract

The leaves and stem of *J. nigra* were collected from the field and rinsed in water to remove dust and soil particles, and then air-dried for 30 minutes to remove surface water. The plants were pulverized using a manual grinder (Crownstar Products, Nigeria); and 1000g of the pulverized plant sample were macerated in 1 litre of distilled water for 72 hours (3 days) with intermittent agitation to obtain a stock solution of 1 g/ml (Uzoma *et al*., 2018).

The extract obtained after this process was used as 100% (1000g/L) concentration of the leaves aqueous extract of *J. nigra*. Further dilution with distilled water was used to obtain other concentrations (25%, 50% and 75%) of the plant extract.

Sand sterilization and determination of pH

Sand obtained from river bank (4.885°N, 7.174°E) was sterilized by soaking in boiled water (100°C) for 15 minutes, and then allowed to cool. This was done to remove inherent seed bank and plant pathogens. The pH level was determined using a pH meter (Suptra Scientific, Canada), and was augmented up to pH of 7.0±0.3 by adding drops of 1M NaOH.

Establishment of allelopathic relationship

Plastic pots (with diameter of 14 cm and depth of 6 cm) were filled with 1kg of sterilized river bed sand. The seeds were planted and watered, and observations were taken from 2 weeks after planting (2WAP), 4WAP, 6WAP and 8WAP. The seedlings were each treated with different concentrations of *J. nigra* extract as follows; 0 (which served as control), 25, 50, 75 and 100%. At termination, data were taken on the fresh weight and dry weight of plants.

Experimental Design

The experiment was conducted adopting a Complete Randomized Design (CRD).

Parameters Studied

- **Plant Height (HOP)**
  The plant height was measured in centimeter (cm) using metric rule.
- **Number of Leaves (NOL)**
  This was measured by the visual counting of the number of leaves in each plant

Data Analysis

SAS version 9.1 was statistical software employed. Data collected were subjected to Analysis of Variance (ANOVA). The means were separated using least significant difference at 5% level of probability. The effects of the various treatments were compared parametrically using the Ochekwu Comparative Treatments Average (OCTA) Trend.

RESULTS

After the treatments were effected, the results for the NOL and HOP for *Tritichum aestivum* and *Oryza sativa* were captured in a graphical plot as represented below:

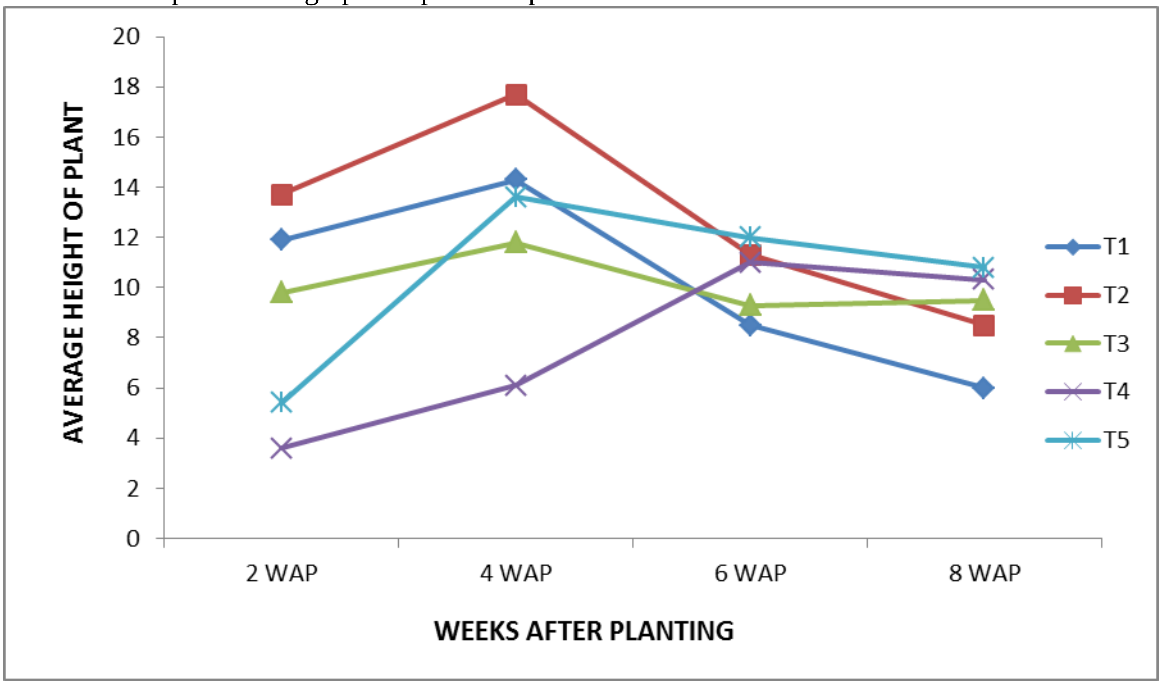

Figure 1: HOP FOR *T. aestivum*

The average height of *T. aestivum* decreased generally, T4 as an exception, with increasing concentration of treatment over the duration of study. The lowest HOP was observed at 8 WAP for all treatments except T4. The lowest plant height was observed for T1 (Figure 1).

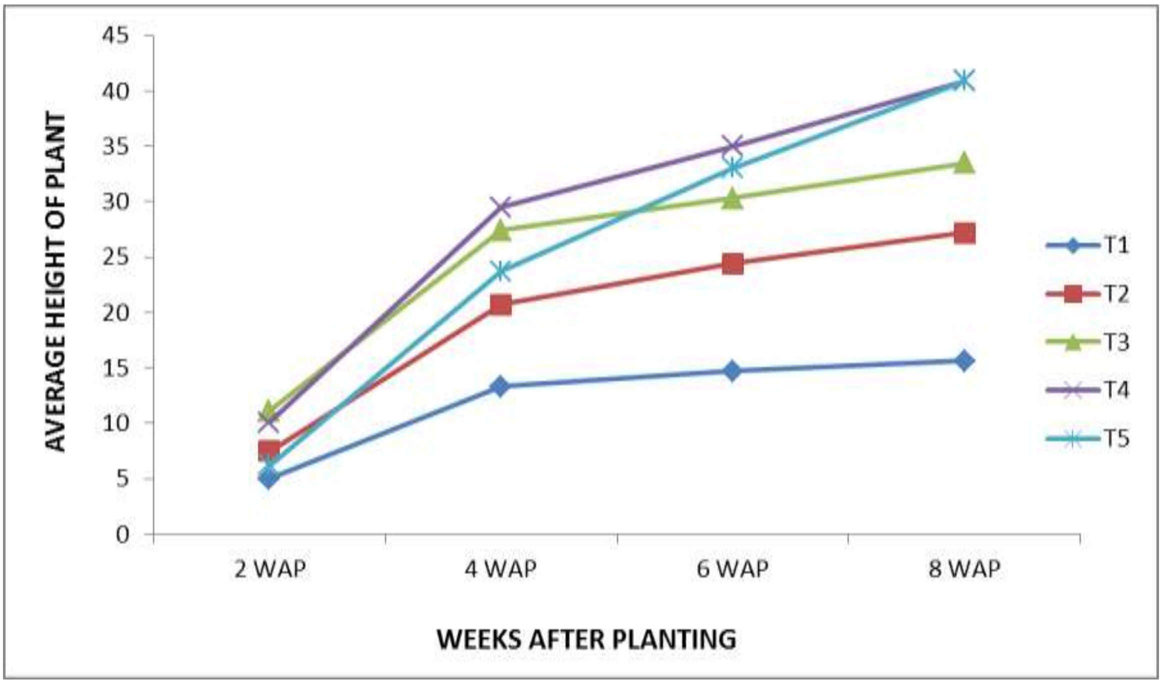

Figure 2: HOP OF *O. sativa*

The average height of *O. sativa* increased generally with increasing concentration of treatment over the duration of study. The highest plant height was observed at 8 WAP for all treatments. The highest HOP was recorded for T4 and T5 (Figure 2).

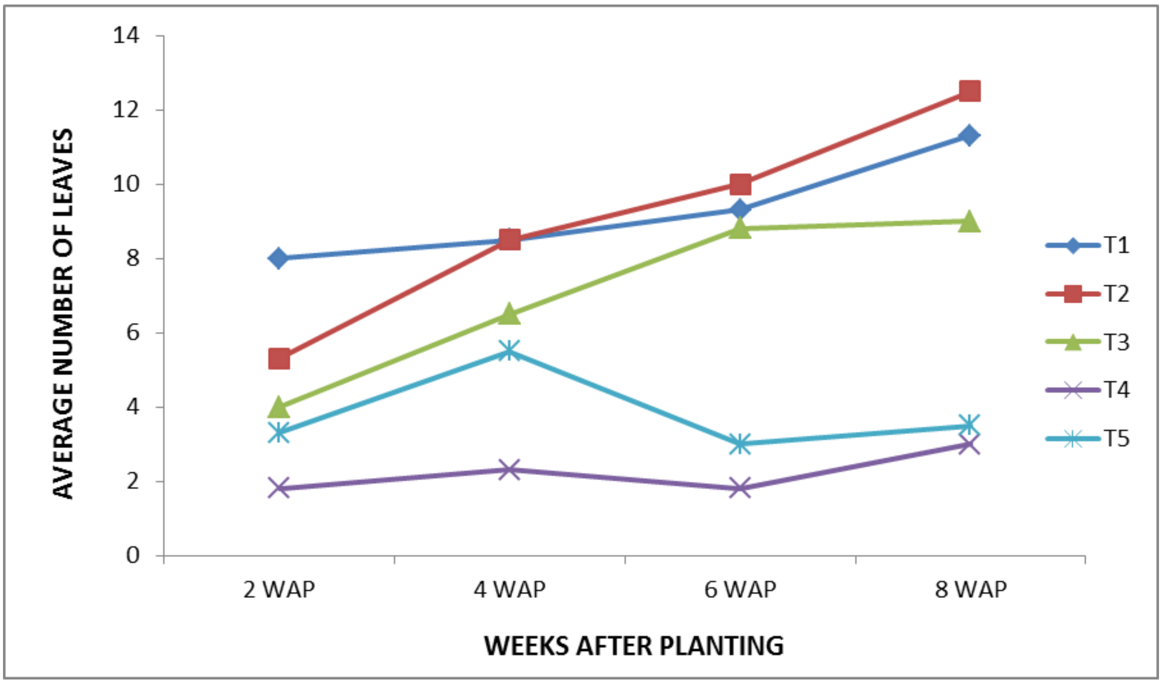

Figure 3: NOL FOR *T.aestivum*

The average number of leaves of *T. aestivum* did not follow any particular trend, with the lowest number of leaves observed at T4 and the highest observed at T2 (Figure 3).

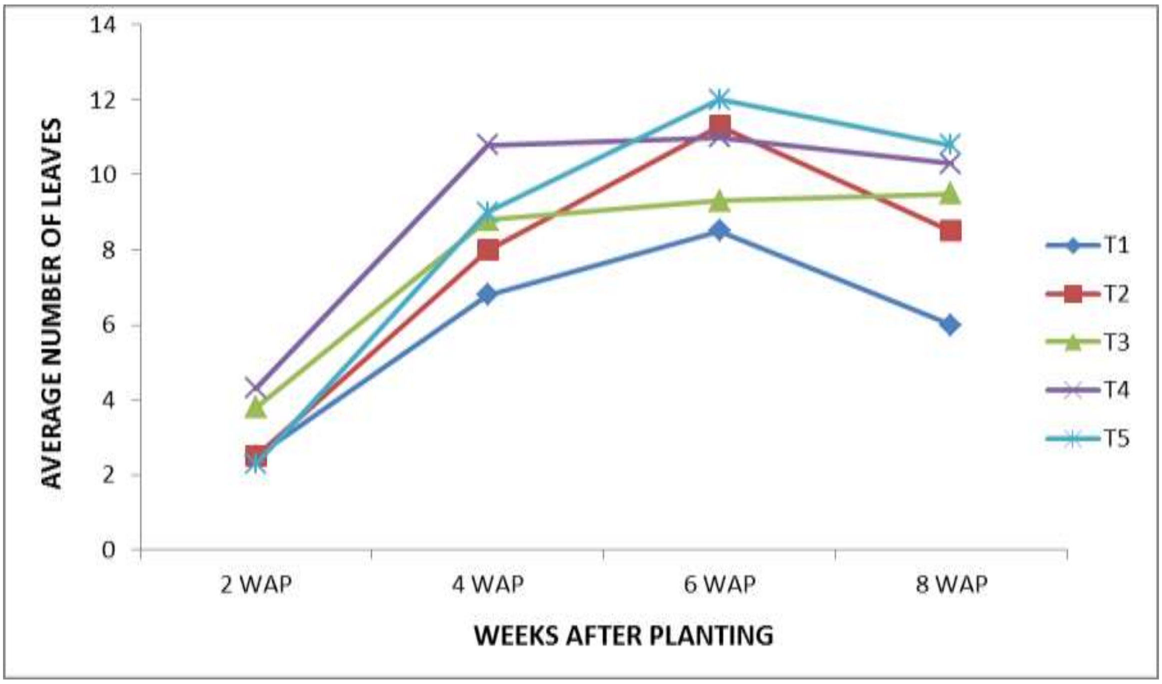

Figure 4: NOL FOR *O. sativa*

The average number of leaves of *O. sativa* increased with increasing concentration of treatment. The highest NOL for all treatments were observed at 6 WAP. The lowest number of leaves were observed at T1 and the highest observed at T5 (Figure 4).

OCTA Analyses

Using the Ochekwu Comparative Treatment Average (OCTA) to determine the Relative OCTA Trend which would show how the respective treatments compared against each other for the particular parameter over the duration under study, the following plots wee deduced:

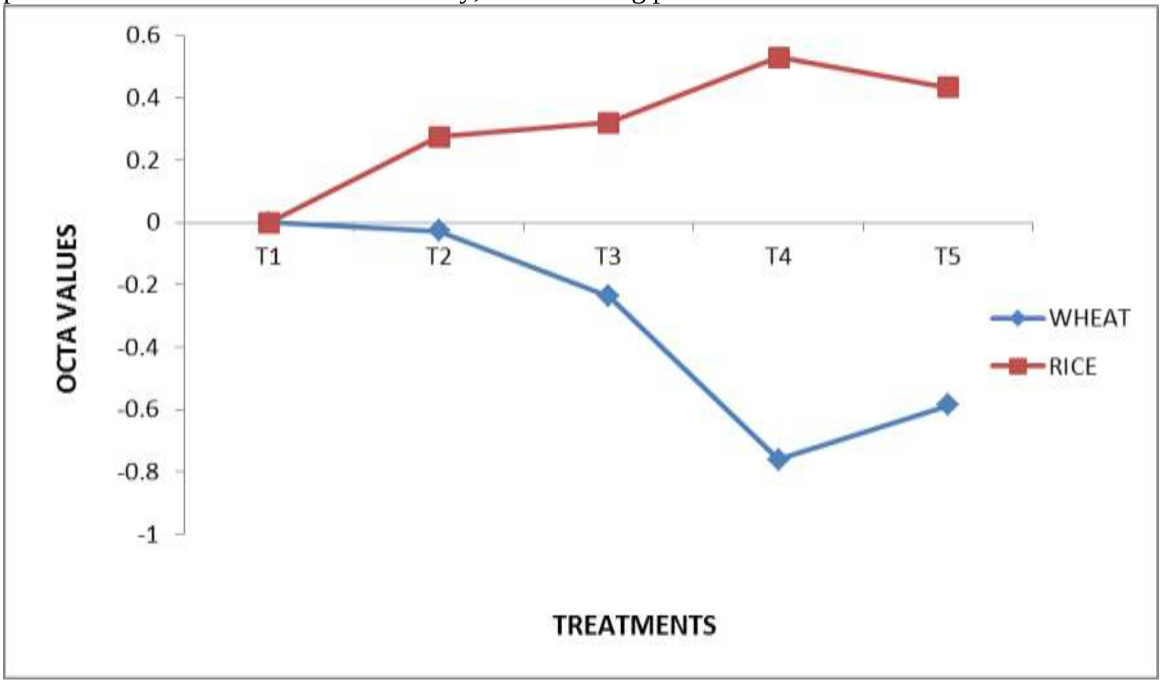

Figure 5: RELATIVE OCTA TREND FOR NOL OF *T. aestivum* AND *O. sativa*

The Relative OCTA Trend for number of leaves for *T. aestivum* and *O. sativa* showed that, while the treatments increased the number of leaves for *O. sativa*, the number of leaves for *T. aestivum* reduced with increasing treatment. T4 showed to be the extreme treatment, recording the highest (the peak) for *O. sativa* (recording an OCTA Index of 0.529) and lowest (trough) for *T. aestivum* (recording an OCTA Index of -0.76) (Figure 5).

The Relative OCTA Trend automatically explains that T4 increased the number of leaves (NOL) of *O. sativa* by 52.9% while it reduced the number of leaves (NOL) of *T. aestivum* by 76% as compared to the control (T1).

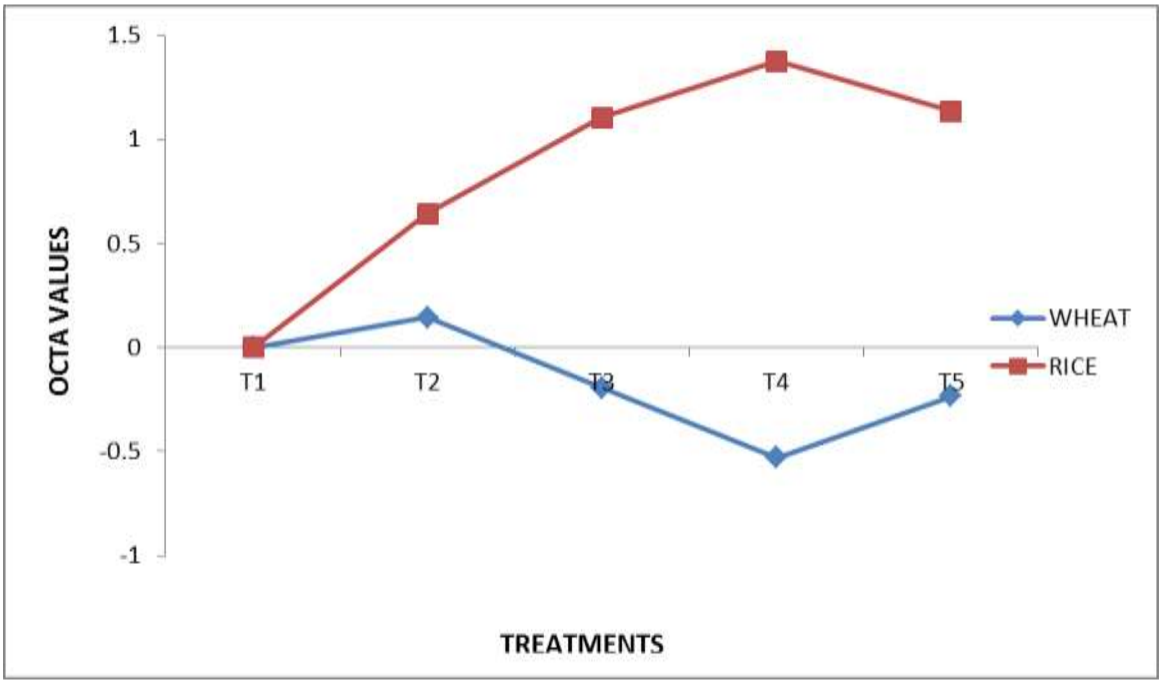

Figure 6: RELATIVE OCTA TREND FOR HOP OF *T. aestivum* AND *O. sativa*

The Relative OCTA Trend for average height of plant (HOP) for *T. aestivum* and *O. sativa* showed that, while the treatments increased the height of plant for *O. sativa*, the height of plant for *T. aestivum* was reduced with increasing treatment. Similar to Figure 5, T4 showed to be the extreme treatment, recording the highest (the peak) for *O. sativa* (recording an OCTA Index of 1.377) and lowest (trough) for *T. aestivum* (recording an OCTA Index of -0.529) (Figure 6).
The Relative OCTA Trend automatically explains that T4 increased the average height of plant (HOP) of *O. sativa* by 137.7% while it reduced the average height of plant (HOP) of *T. aestivum* by 52.9% as compared to the control (T1).

DISCUSSION
The study showed that the extracts of *J. nigra* negatively affected the HOP of *T. aestvum*; although the same cannot be said of its effect on the NOL of *T. aestvum* , which followed a slight increase as with increasing duration (WAP). The slight increase in number of leaves (NOL) for *T. aestvum*, despite a reduction in height shows that the negative allelopathic effect of *J. nigra* may only affect the height of plants (HOP). Though this phenomenon is not fully understood, but the increased NOL was anticipated with time, as the NOL of a plant is not established as being dependent on the height of the plant.
It was also observe that the increase in the concentration of the extract of J. nigra significantly improved the HOP and NOL for *O. sativa* over time (WAP). This finding comes as a surprise, as the notoriety of *J. nigra* as a negatively allelopathic plant is widely established. Therefore, this finding goes against the inferences of Kocacaliskan *et al*. (2009), Ercisli *et al*. (2005) and Bajalan *et al*. (2013) who reported the allelopathic notoriety of *J. nigra* on cucumber, strawberry and wheat germination respectively. But, this observation seems to go in line with the reports of Musiyimi *et al*. (2015) who established that applications of fresh shoot aqueous extracts of *Tithonia diversifolia* increased some morphological growth parameters of *Vigna sinensis*. Musiyimi *et al*. (2015) further suggested that the stimulatory effect on the morphological growth parameters of *V. sinensis* corresponded to similar increase in total chlorophylls content of *V. sinensis*. Similar work have been done by Uzoma *et al*. (2019) who established that the aqueous extracts of *Axonopus compressus* increased the growth parameters of *Kalanchoe pinnata*. Uzoma et al. (2018) established that the application of aqueous extracts of *A. compressus* increased the phenolic and chlorophylls content of *K. pinnata*, and therefore

suggested that the increase in the growth parameters of *K. pinnata* due to the application of the aqueous extract of *A. compressus* could be traced to an increased chlorophyllase activity.

Following the Ochekwu Comparative Treatment Average (OCTA) Trend, it was established that on a general and holistic extrapolation, the treatments, over time, negatively influenced both the HOP and NOL of *T. aestvum* (as compared with the control), with the extreme troughs at T4 (OCTA values of -0.529 and -0.76 respectively). This observation keys in line with the reports establishing the negative allelopathic notoriety of *J. nigra*. These reports have been made on Cucumber (Kocacaliskan *et al*., 2009), Strawberry (Ercisli *et al*., 2005) and even on the seed germination of wheat (Bajalan *et al*., 2013).

The turning point of this study came with the finding that, on a holistic extrapolation, the increase in the concentration of the extract positively improved the HOP and NOL of *O. sativa* over time (as compared with the control), with the extreme peaks at T4 (OCTA values of 1.377 and 0.529 respectively). This suggests a bio-fertilizer potential of *J. nigra*, and therefore defies the promulgations of Kocacaliskan *et al*., (2009) ,Ercisli *et al*., (2005) and Bajalan *et al*., (2013) who emphasized the negative allelopathic effect of *J. nigra* on several crop plants. But, this finding is supported by the work of Uzoma *et al*. (2019) who explained that *Axonopus compressus* extract showed a positive allelopathic effect on *Kalanchoe pinnata*, which he attributed to increased chlorophyllase activity.

A careful observation of the OCTA Trend for the HOP and NOL of *T. aestivum* and *O. sativa* showed that, while extracts of *J. nigra* negatively influenced the growth parameters of *T. aestivum*, it positively influenced the growth parameters of *O. sativa*. This bilateral influence of *J. nigra* on two species of the Poaceae family suggests that the allelopathic interaction or effect of a plant on another depends particularly on the two specific plants interacting, and thus cannot be generalized, even if the recipient plants are from the same family. Hence, while *J. nigra* inhibited the growth parameters of *T. aestivum*, it improved those of *O. sativa* – despite both being of the same family. Though the physiological mechanism behind this bilateral influence is not yet established, but this bilateral influence could actually serve as a pointer to the slight biochemical differences between the two plants, despite their phylogeny.

CONCLUSION

J. nigra, despite being notoriously reported as being negatively allelopathic, exhibits bilateral influence on plants, even at the family level. Hence, *J. nigra* inhibited the height and number of leaves for *T. aestivum*, while increasing the height and number of leaves of *O. sativa*, despite both being of the same Poaceae family. This bilateral influence also serves as a pointer to certain biochemical differences between the two plants, despite their phylogenetic similarity.

It is therefore advised that, while *J. nigra* should not be intercropped with *T. aestivum*, its extracts should be added to *O. sativa* flood farms as a bio-fertilizer.

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