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Allelopathic Effect Of the Root Exudates of *Tithonia diversifolia* on the Germination, Growth and Chlorophyll Accumulation of *Amaranthus dubius* L. and *Solanum melongena* L.

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ABSTRACT

The allelopathic activity of the root exudates of *Tithonia diversifolia* on the germination, growth and chlorophyll contents of *Amaranthus dubius* L. and *Solanum melongena* L. plants were evaluated . The germination of both test crops, the shoot length and leaf area of *A. dubius* were significantly inhibited at $p<0.05$ while accumulation of chlorophyll was significantly enhanced at $p<0.05$. The root exudates had no significant effect on the growth and chlorophyll content of *S. melongena*. The study suggested that interaction with the target plant species affected the viability and biological activity of the allelochemicals released from the roots of the donor plant. The mode of action of the allelochemicals was target plant species dependent since the concentration threshold that would effect allelopathy differ from one target plant species to the other.

Key words: Allelopathic potential, root exudates, allelochemicals, *Amaranthus dubius*, *Solanum melongena*

INTRODUCTION

Allelopathy is a phenomenon whereby secondary metabolites synthesized by fungi, viruses, microorganisms and plants influence biological and agricultural systems which may be either stimulatory or inhibitory (Farooq *et al.*, 2011). Allelochemicals are plant secondary metabolites normally released into the environment through volatilization, leaching, root exudation and decomposition of plant residues in the soil (Khalaj *et al.*, 2013). According to Khanh *et al.* (2007), allelochemicals are secondary metabolites like terpenoids and phenolics compounds (flavonoids, anthocyanins, lignin, tannins) which have specific actions. The effects of allelochemicals action are detected at molecular, structural, biochemical, physiological and ecological levels of plant organization (Gniazdowska and Bogatek, 2005).

In recent years there has been an increased interest in the effect of application of allelochemical mixtures on the germination and growth of target plants. A large number of plants impose inhibitory effects on the germination and growth of neighbouring or successional plants by releasing allelopathic chemicals into the soil (Alam and Islam, 2002; Khan *et al.,* 2009). Narwal *et al.* (2002) reported that aqueous extract of the root of *Helianthus annus* delayed and inhibited the germination and seedling growth of linseed (*Linum usitatissium* L.) and mustard (*Brassica juncea* L.). The water extracts from tissues of *Helianthus annus* were observed to inhibit germination of *Solanum nigrum* (Sedigheh *et al.*, 2010). According to Nekonam *et al.* (2013), aqueous extracts of *Crocus sativus*, *Ricinus communis*, *Nicotiana tabacum*, *Datura inoxia* and *Sorghum vulgar* significantly inhibited germination of field bindweed (*Convolvulus arvensis*). Aqueous extracts from the leaves of *Helianthus tuberosus L., Xanthium occidentale, Lactuca sativa* and *Cirsum japonica* all in the Asteraceae family inhibited the root growth of Lucerne (Chon *et al.*, 2003). According to Abu-Romman *et al.* (2010), the aqueous leaf leachates of *Euphorbia hierosolymitana* reduced the shoot height of wheat (*Triticum durum*). Swapnal and Badruzzaman (2010) reported that the root length, shoot length of *Melilotus alba* Medik., *Vicia sativa* L. and *Medicago hispida* Gaertn. decreased progressively when the plants were exposed to increasing concentration of the extract of *Croton bonplandianum* Baill. An *et al.* (2013) stated that the root exudates of Switchgrass (*Panicum virgatum* L.) reduced lettuce (*Lactuca sativa* L.) seedling growth. The aqueous extracts of leaves of water extracts from the leaves of *Eucalyptus camaldulensis, Acacia nilotica, Helianthus annuus* and *Parthenium hysterophorus* significantly decreased the shoot length, root length, fresh and dry weight of shoot, fresh and dry weight of root of wheat (Ullah *et al.*, 2013).

Decrease in chlorophyll content in the presence of allelochemicals was reported by Baziramakenga *et al.* (1994) and Zeng *et al.* (2001). The debris of *Fimbristylis miliacea* reduced the chlorophyll content of rice seedlings (Siddique and Ismail, 2013). Also, Abdul Raoof and Siddiqui (2013) observed that chlorophyll and protein contents of *Chenopodium album* L., *Chenopodium murale* L., *Cassia tora* L. *and Cassia sophera* L. were reduced by aqueous leaf leachate of *Tinospora cordifolia*. Yang *et al.* (2002) stated that chlorophyll biosynthesis of rice seedlings are inhibited by exogenously applied allelochemicals. Masura *et al.* (2002) observed that allelochemicals could inhibit the enzyme protoporphyrinogen oxidase and therefore lead to alteration in chlorophyll biosynthesis. These authors further stated that the retardatory effects on photosynthesis could then be the result of an alteration in chlorophyll degradation pathway and inhibition of carotenoid biosynthesis.

Tithonia diversifolia, the donor plant in this study is a weed common in the Western part of Nigeria which associates with common cultivated crops like vegetables, cassava, yam, rice, sorghum soybeans etc. (Akobundu and Agyakwa, 1987). Previous works done in our lab indicated that the fresh shoot aqueous extract of *T. diversifolia* inhibited the radical growth of *Oryza sativa* (Ilori *et al.*, 2007) and the shoot growth of *Amaranthus cruentus* (Otusanya *et al.,* 2007). Available literature indicates that no allelopathic studies have been done on the root exudates of Nigerian *T. diversifolia*. Thus the main objective of this study was to evaluate the allelopathic capacity of water soluble root exudates of *T. diversifolia* on the germination, growth and chlorophyll contents of *Amaranthus dubius* L. and *Solanum melongena.*

MATERIALS AND METHODS

Good humus top soil was put into plastic pots (28×15 cm). Ten seeds of *T. diversifolia* (the donor plant) were sown in each pot and watered with 400 mL of tap water every morning. The capillary water which percolated through the soil and drained out through perforated holes at the bottom of the plastic pots containing only the donor plant was used as Root Exudate Treatment (RET) for the test crops.

Germination experiment: Two of the most common Nigerian vegetable species used in this study were *Amaranthus dubius* and *Solanum melongena*. Healthy seeds of the test crops were surface sterilized with 5% sodium hypochlorite and thoroughly rinsed with distilled water. Thereafter, ten seeds of each of the test crops were placed in each clean oven dried petri-dish which had been lined with a Whatman No 1 filter paper. The filter paper in each of the petri-dishes allocated to the control was moistened with 10 mL of distilled water while that of the petri-dishes allocated to the other treatments were moistened with 10 mL of the root exudates. Emergence of 1 mm of the radicle was used as the criterion for germination.

Pot experiment: Seeds of the test plants were sown in each of the pots filled with humus top soil and watered with 400 mL of tap water every morning. At two weeks, seedlings in each pot were thinned down to ten seedlings per pot. The pots containing the test crops were allocated to the control and the root exudates treatment. Thereafter, the pots in the control regime were supplied with 400 mL tap water daily while the pots in the root exudates regime were supplied with 400 mL of the capillary water which percolated through the soil and drained out through perforated holes at the bottom of the plastic pots containing only the donor plant. The pots were laid out in a completely randomized design. Harvesting of the seedlings was on weekly interval. The shoot height, root length, leaf breadth and leaf length of the two test crops were measured using meter rule. The leaf area was determined using the formula of Pearcy *et al*. (1989):

$$LA = 0.5\ (L\times W)$$

Where:
L = Length of leaf and
W = Maximum width of leaf

Fresh plants parts were weighed on Mettler Toledo balance to obtain fresh weights of plant parts. The plants parts were then packaged in envelop separately and dried at 80°C in a Gallen Kamp (model IH-150) incubator to constant weight to obtain the dry weight of the plant parts. Chlorophyll contents were determined using the method of Comb *et al*. (1985). The data obtained were analy sed by Analysis of Variance (ANOVA) to determine significant ($p<0.05$) effects.

RESULTS

There was reduction in the percentage germination of *A. dubius* L. and *S. melongena* L. seeds treated with the root exudates of *T. diversifolia* compared to the control seeds by 91-72.5% and 53.3-12.5%, respectively (Fig. 1). The effects of the water soluble root exudates on the shoot height,root length, leaf area, fresh weight, dry weight and total chlorophyll content of *A. dubius*

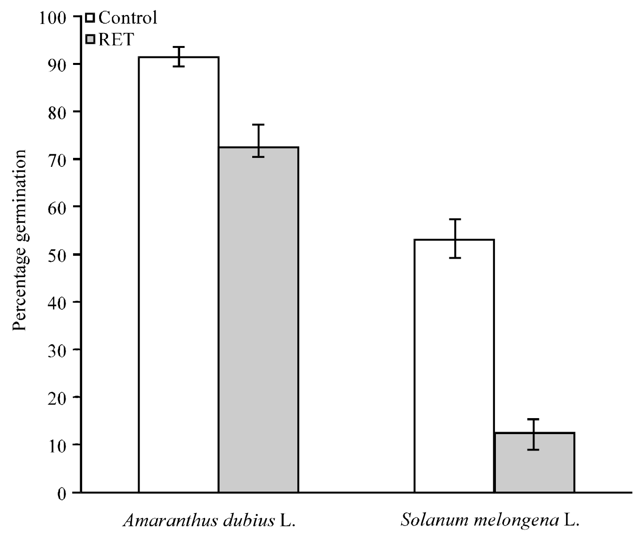

Fig. 1: Effect of the root exudates of *T. diversifolia* on the germination of *Amaranthus dubius* L. and *Solanum melongena* L.

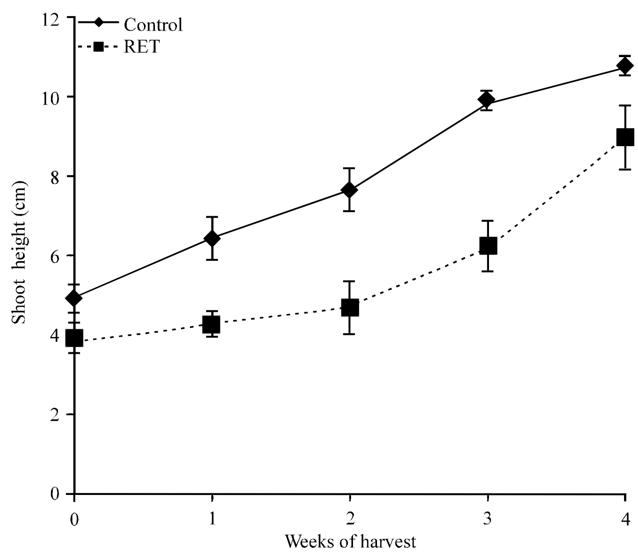

Fig. 2: Effect of the root exudates of *T. diversifolia* on the shoot height of *Amaranthus dubius* L.

plants are shown in Fig. 2-7. The shoot height, root length and leaf area of *A. dubius* plants treated with root exudates were significantly reduced at $p \leq 0.05$. The fresh and dry weight of *A. dubius* plants treated with water soluble root exudates *T. diversifolia* were not significantly different from those of the plants in the control regime. The total chlorophyll content of the treated plants were however higher and significantly different ($p<0.05$) from those of the plants in the control regime. The effect of water soluble root exudates on the growth parameters and chlorophyll content of *S. melongena plants* is shown in Fig. 8-13. The plant shoot height, root length, leaf area, fresh weight, dry weight and total chlorophyll content of *S. melongena* in the control regime were higher but not significantly different at $p \leq 0.05$ from those of the treated plants.

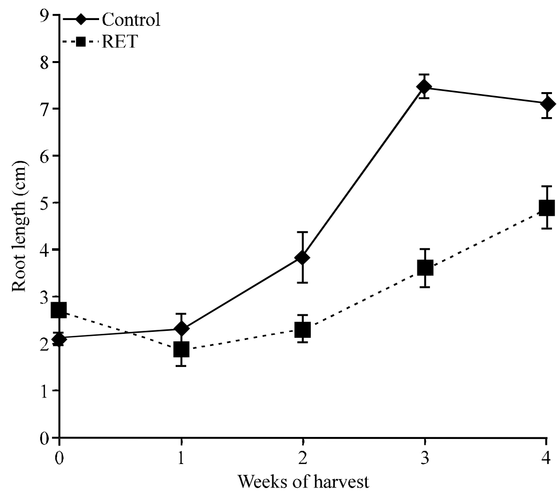

Fig. 3: Effect of the root exudates of *T. diversifolia* on the root length of *Amaranthus dubius* L.

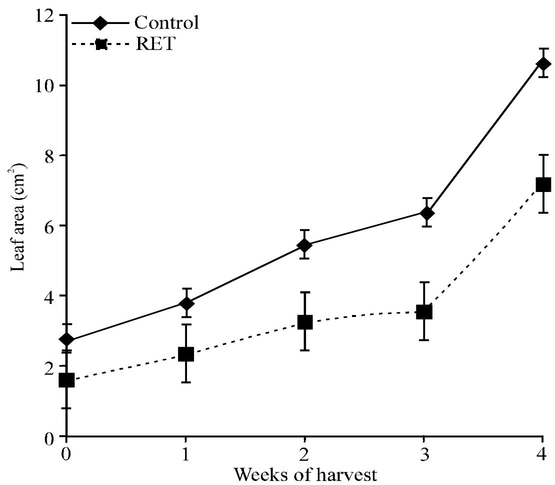

Fig. 4: Effect of the root exudates of *T. diversifolia* on the leaf area of *Amaranthus dubius* L.

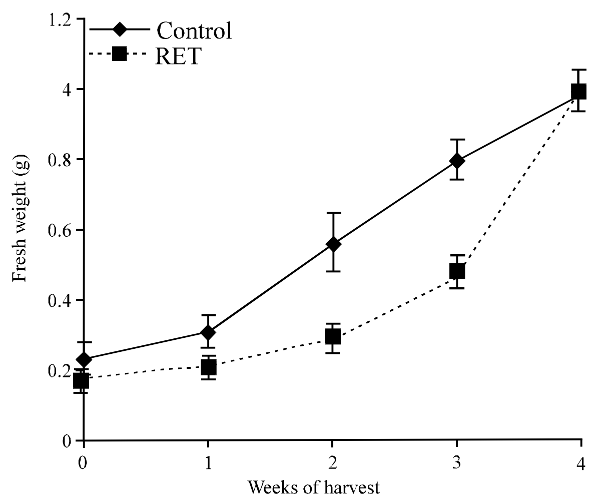

Fig. 5: Effect of the root exudates of *T. diversifolia* on the fresh weight of *Amaranthus dubius* L.

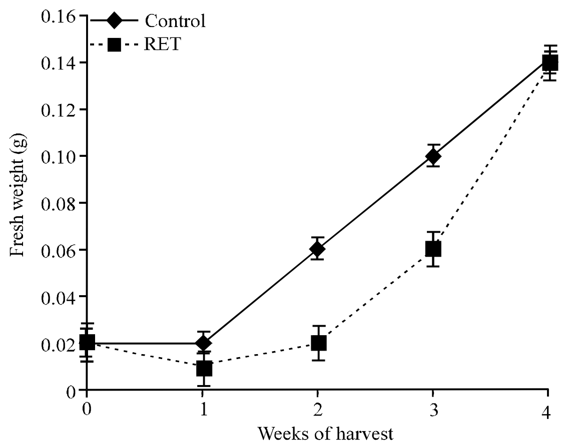

Fig. 6: Effect of the root exudates of *T. diversifolia* on the fresh weight of *Amaranthus dubius* L.

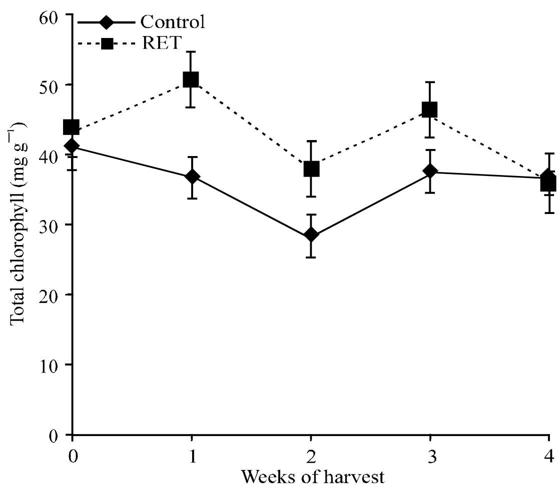

Fig. 7: Effect of the root exudates of *T. diversifolia* on the total cholorophyll of *Amaranthus dubius* L.

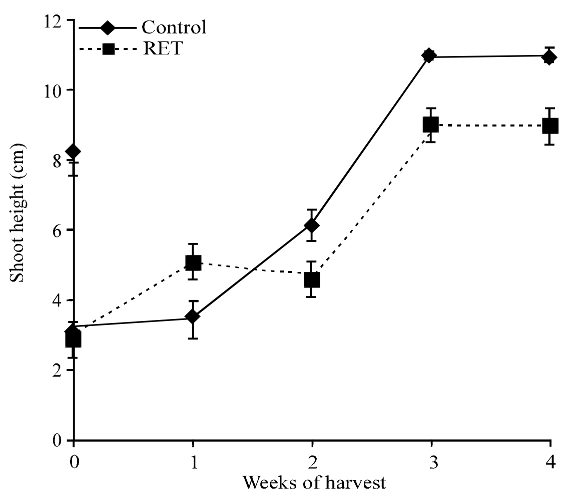

Fig. 8: Effect of the root exudates of *T. diversifolia* on the shoot height of *S. Melogena* L.

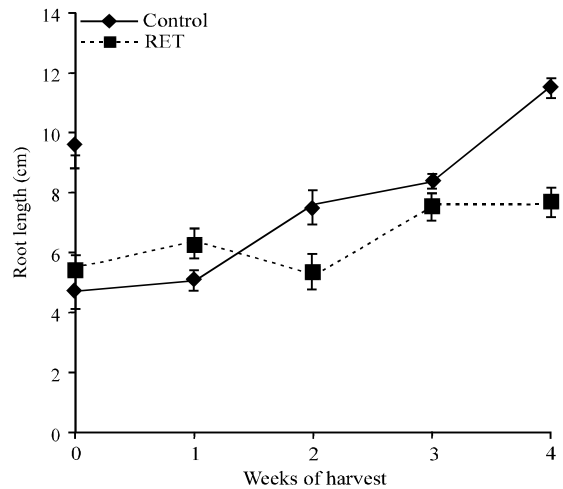

Fig. 9: Effect of the root exudates of *T. diversifolia* on the root length of *S. melongena* L.

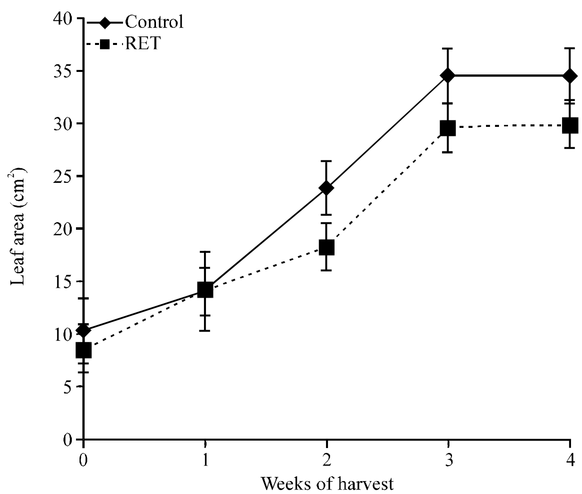

Fig. 10: Effect of the root exudates of *T. diversifolia* on leaf area *S. melongena* L.

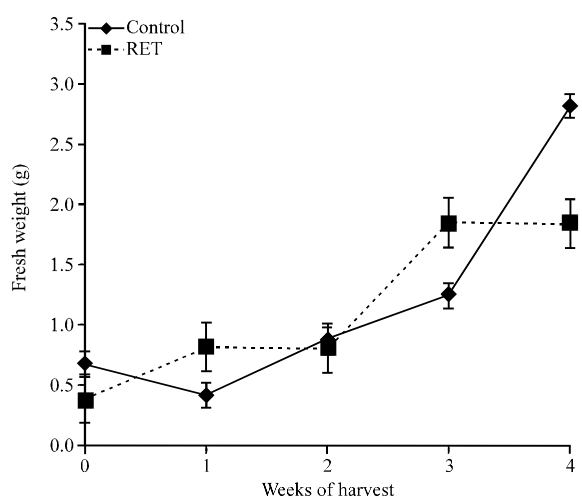

Fig. 11: Effect of the root exudates of *T. diversifolia* on the fresh weight of *S. melongena* L.

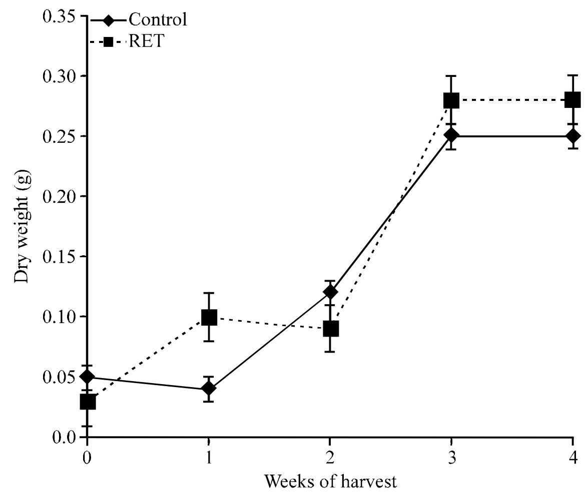

Fig. 12: Effect of the root exudates of *T. diversifolia* on the dry weight of *S. melongena* L.

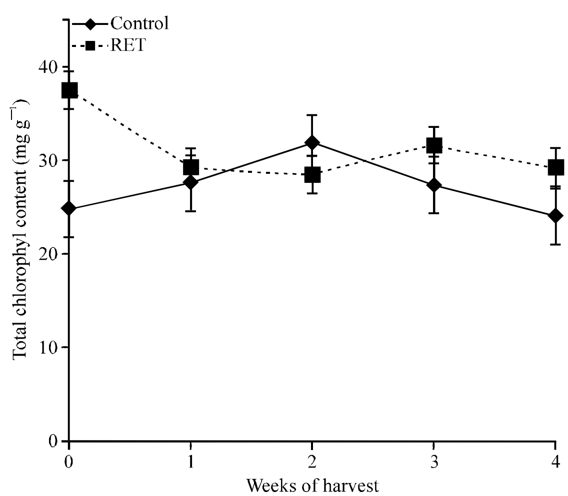

Fig. 13: Effect of the root exudates of *T. diversifolia* on the total chlorophyll content of *S. melongena* L.

DISCUSSION

The inhibitory effects and in some cases stimulatory effects of *T. diversifolia* extracts on germination and growth of *Oryza sativa, Amaranthus cruentus* and *Zea mays* have been reported (Ilori *et al.,* 2007; Otusanya *et al.,* 2007; Oyerinde *et al.*, 2009). In this study, the root exudates of *T. diversifolia* inhibited the germination of *A. dubius* L. and *S. melongena* seeds. This was consistent with the work of Wakjira *et al.* (2005) who reported that aqueous extract of P*arthenium hysterophorus* leaves and flower inhibited seed germination of lettuce. Javed and Asghari (2008) also reported that the leaf extract of *Helianthus annus* inhibited the germination of wheat seeds. The shoot height, root length and leaf area of *A. dubius* L plants were significantly reduced by the application of root exudates while those of *S. melongena* were not affected. This was inconsistent with the findings of Hussain *et al.* (2007) who stated that *Senna* extract promoted the growth of *Avena fatua, Dectyloctenium aegyptium* and *Echinocloa colona.* However, the result agreed with the report of Tongma *et al.* (1997) who found that there was a decrease in shoot and root growth of rice grown in soil previously planted with *T. diversifolia* while seed germination was not found to be affected. The water extracts from leaves of *T. diversifolia* added to the soil and the soil water separated from such soil reduced shoot and root growth of rice (Tongma *et al.*, 1998). Taiwo and Makinde (2005) observed that the aqueous extract of *T. diversifolia* enhanced the growth of cowpea (*Vigna unguiculata*). Chengrong *et al.* (2005) similarly found that allelochemicals from *Wedelia troblabata* reduced germination, plants height, fresh and dry weights root and shoot per plants of rice. Batish *et al.* (2006) also reported that aqueous leachate of *Chenopodium album* plant parts (root, whole plant and leaf) inhibited the germination, plant height, growth and biomass of *Cassia occidentalis*.

According to Yang *et al.* (2002) the influence of allelochemical on photosynthesis in target plants can also be estimated indirectly through chlorophyll content reduction. The total chlorophyll content of the *A. dubius* L. plants treated with root exudates were higher and significantly different from those of the plants in the control regime. This was contrary to the finding of Rice (1984) who stated that some allelopathic compounds might interfere with the synthesis of porphyrin which is a precursor of chlorophyll thereby leading to a reduction of chlorophyll accumulation. The root exudates of *T. diversifolia* however had no adverse effect on growth and total chlorophyll content of *S. melongena*. The concentration threshold of the allelochemicals in the root exudates of *T. diversifolia* that would have potential allelopathic effect therefore differ from one target species to another.

CONCLUSION

The study showed clearly that the mode of action of allelochemicals released from the roots of *T. diversifolia* was target plant species dependent and thus emphasized the fact that biotic factors such as target plant species, affect the viability and biological activity of the allelochemicals in the root exudate.

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