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STUDY OF ROOT GROWTH PARAMETERS OF PLANTS (*GLYCINE MAX* L., *VIGNA SUBTERRANEA* L. AND *ZEA MAYS L.)*IN DIESEL OIL POLLUTED SOIL

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Abstract

A field trial study was conducted in 2010 to investigate the study of root growth parameters of plants (*Glycine max L. , Vigna subterranean L.* and *Zea mays L.*) in diesel oil polluted soil in Owerri, Imo State, Nigeria. The experiment was split-plot design based on randomized complete block design. The crop plants constituted the main plots and diesel oil pollution levels (0, 1.0, 1.5 and 2.0 litres) constituted the sub plots and each treatment was replicated five times. The result showed that diesel oil pollution at all levels significantly affected growth parameters of *Glycine max, Vigna subterranean and Zea mays L.* The result indicated that number of roots, root lengths and root dry weights were significantly reduced by treated plots (1.0, 1.5 and 2.0 liters pollution levels respectively) compared to the control plots. The relative growth rate (RGR) was found to be affected by time of analysis, level of diesel oil pollution and crop specie. Comparatively *Glycine max L.* (soybean) at early stage of growth performed significantly better in number of roots than *Zea mays L.* (maize) and *Vigna subterranean L.* (Bambara groundnut). At maturity stage, maize plant performed better in root length and dry weight in 2.0litres pollution level than soybean and Bambara groundnut showing tolerance. This study have shown that diesel oil pollution at high dose reduced root growth parameters which adversely affected growth and development of these crop plants ,thereby causing reduction in yield subsequently hunger and disease in society.

***Key words*:** Root, Growth parameters, diesel oil, polluted soil.

Introduction

Roots improve soil aeration by directly giving off oxygen to the root zone as well as allowing improved entry of oxygen into soil by diffusion along channels (Nye and Tinker 1977, Issoufi *et al*., 2006). Root enhances microbial activity in the region adjacent to the roots, the rhizosphere, which may stimulate bioremediation of hydrocarbon (Issoufi *et al*., 2006). Root may also reduce movement of contaminates in soil by extracting excess water, thus reducing the downward flow of water (Topp *et al*., 1986, Nair *et al* ., 1993, Vlamis *et al*., 1985; Issoufi *et al*., 2006).

Plant root depth becomes important since it is generally accepted that the physical and biological conditions favouring degradation of organic pollutants decreases with increasing soil depth (Oslon *et al.,* 2001). Vidali (2001) suggested that in many soils effective oxygen diffusion for desirable rates of biodegradation extent to a range of only a few centimeters to 30cm into the soil profile.

Understanding of influence of petroleum hydrocarbon which are phytotoxic on plant establishment and development is also essential in assessing the potential of a plant for remediation (Ceric *et al.*, 2007). The effect on the development of root system is particularly important because of crucial role played by rhizosphere. Several experimental studies have investigated on the phytotoxic effect of petroleum hydrocarbon on seed germination and seedling and plant development (Chaineau *et al*., 1997; Adam and Ducan 1999, 2002, 2003; Kroening *et al*., 2001; Ceric *et al.*, 2007). However studies about the influence of diesel on root systems are generally limited to data on the root biomass (Xu and Johnson, 1995; Hou *et al*., 2001; Lin *et al.*, 2002). The aim of this field trial was to study growth and development of root growth parameters of plants in response to diesel oil pollution.

Materials and Methods

Certified seed of Bambara groundnut, Soybean and Maize were obtained from Imo state agricultural programme (IMOADP).The land was manually cleared. The soli was ploughed and raised to beds of 1m x1mx0.75m.Different levels (0,1.0, 1.5 and 2.0litres) of diesel oil contaminants were poured on the beds which was then incorporated by pulverizing the soil using a spade to achieve even distribution of the diesel oil. These were left for 7days before planting in order to enable the volatile substances which are toxic to plant to escape into atmosphere. The treatment was replicated five times.

Planting of soybean and bambaragroundnut seeds were sown at a depth of 2cm with spacing of 10cm x 10cm at the rate of 2 seeds per hole. The maize seeds were planted at the same depth as above with spacing of 30cmx30cm at the rate of 2 seeds per hole. Data on Root lengths, number of roots, root dry weights and relative growth rate (RGR) where taken at 2 weeks interval. Difference among treatments were tested using analysis of variance followed by Duncan multiple range test (SPSS for window version 13.00).

Results

Number of Root

Control treatment recorded highest number of root in Bambaragroundnut, maize and soybean at 2, 4, 6, 8 and 10WAP which was significantly difference ($p<0.05$), compared to the 2.0litres pollution level. However at 10WAP, soybean in 0, 1.0, and 1.5 pollution levels respectively, significantly recorded higher number of root compared to the Bambaragroundnut and maize. Whereas at 10WAP, in 2.0 litre pollution level, maize plant significantly recorded higher number of root than observed in soybean and bambaragroundnut (figure 1).

Root Length

In figure 2,Control treatment, recorded higher root lengths in Bambaragroundnut at 8WAP and 10WAP which were significantly different ($P<0.05$) compared to the root lengths recorded in soybean and maize respectively. Also the same trend was observed in T_2 pollution levels. However in 1.0 and 2.0litres pollution level at 10WAP, maize recorded better root length than Bambaragroundnut and soybean respectively. The root growth was differentially reduced by 1.0, 1.5 and 2.0litres treatment levels. However, 1.5 and 2.0 litres impacted heavily on soybean and bambaragroundnut at the end of growth period than maize plant.

Root Dry Weight

Effects of treatment were significant at all the growth stages. At 2, 4, 6, 8 and 10WAP, maize plant recorded higher root dry weight in all treatment levels which was significantly different ($p<0.05$) compared with the lower root dry weights recorded in soybean and bambaragroundnut respectively as shown in figure 3. Also 2.0 litres was found to significantly reduced root dry weight in the test crops compared to the control.

Relative growth rate (RGR)

Mean relative growth rate of roots were consistently dependent on time of harvest, level of pollution and crop species as shown in fig. 4. At 2 and 4 WAP, Soybean recorded high root RGR in 2.0 litres pollution level which was not significantly difference from root RGR recorded in control by maize plants and bambaragroundnut. At 6 and 8WAP soybean performed better than maize in all treatment levels followed by Bambaragroundnut which at relatively low pollution level (1.0litre) at 6WAP recorded highest RGR (0.342ggm) which was significantly ($p<0.05$) compared to the lowest (0.034ggm) recorded in 2.0litres pollution level by maize. Whereas soybean performed better in RGR towards maturity stage than maize in control and 1.0litre pollution level .

Discussion

The number of roots in Bambaragroundnut, maize and soybean were significantly influenced by specie response and diesel oil levels (figure1). In terms of species response, except at 2WAP, soybean significantly produced greater number of roots than maize and Bambaragroundnut plants. This could be due to ability of soybean to exude materials that increase microbial activities in rhizosphere which could lead to proliferation of roots in search of nutrients. Another reason for this specie difference in number of roots could be due to ecological and biological characteristics of crops (Offor and Akoye, 2006). The decreased in the number of roots recorded in Bambaragroundnut, maize and soybean due to high diesel oil pollution (2.0 litres) at 2,4,6, 8 and 10WAP in contrast to increased number of roots in control could be due to stress imposed by inhibitory effect of some of the diesel oil polycylic aromatic hydrocarbon components which are more soluble than the aliphatic hydrocarbons (Wang and Bertha, 1990; Trapp *et al.*, 2001: Molina-Barahoma *et al.*, 2005). Also it could be due to smearing of plant roots with oil substance forming hydrophobic layer which reduced water absorption and nutrient uptake thereby limiting growth and production of roots. Baran *et al.* 2002 has reported that petroleum derived components on soil leads to severe nitrogen and phosphorus depletion, disruption of water balance and biological equilibrium. Also Njoku *et al.* (2008) reported that major effect of petroleum product to the soil is the disruption of the absorption and uptake of essential nutrient by plant roots.

The root length has been found to be impacted heavily by diesel oil pollution (figure 2). Soybean crop at 4 and 6WAP displayed longer root length than that observed in maize and Bambaragroundnut, whereas maize plant at 8 and 10WAP respectively produced longer root length than soybean and Bambaragroundnut. This variations and fluctuations in specie response according to Offor and Akonye (2006) ,could be to physiological state of the test crops at the time of harvest and on the other hand due to natural variations in their ecological and biological characteristics of these crops.

However, the ability of plant roots to grow in a polluted soil was reduced by the severe diesel oil pollution level (2.0 litres). This could be due to stress imposed by high diesel oil dose, which limit nutrient availability, water uptake and lack of oxygen for root growth. Hydrocarbon affect plant directly, smearing roots of plants with oily substances and thus reducing or limiting transpiration and respiration by plants, reducing permeability of cell membrane, upsetting metabolic conversions leading to changes in the chemical composition and lastly through the toxic of some hydrocarbon on plants (Pazeshiki *et al.*, 2000).

In moderate diesel oil pollution (1.0 litre pollution) gave comparatively high root length which was not significantly difference ($P<0.05$) from the unpolluted soil (control) as observed. This showed that diesel oil pollution stimulate growth in plant. This was attributed to enhance nutrients availability, high microbial activities, and high organic matter content. This increase is attributed to the fact that at lower level of pollution, diesel oil acts rather as a source of nutrient to the organisms which when degraded enhance the fertility of the soil (Ekpo and Ebeagwu (2009).

However, in all, 2.0 litres interaction with crop plants in this study reduced overall root growth in the test crops. This reduction could lead to reduced ability of these crops to absorbed mineral elements which manifested in reduction in N,P,K, content of these test crops. In other hand the effect of control (0.0litre) on Bambaragroundnut, maize and soybean did not show a steady clear distinction between their root lengths at any given stage of harvest. This could be attributed to physiological status of each crop at the time of analysis. Also this could be due to genetic variability in response to ecological characteristics of field soil due to nutrient gradient.

Root development in respect to root dry weight result revealed that crop specie response significantly influenced the root dry weight of Bambaragroundnut, maize and soybean (figure 3). Maize plant, significantly recorded progressive increase in root dry weight from early growth stage (2 and 4WAP) to maturity stage compared to Bambaragroundnut and soybean which after 6WAP showed a progressive reduction in root dry weight towards the maturity stage (10WAP). This genetic variability could be due to ability of each of the test crop to utilize nutrients in synthesis of dry matter and its redistribution to roots for growth. This assertion is still in conformity with finding of Ehiagbonare *et al.* (2011), who reported that the degree and variability of response to petroleum is genetic.

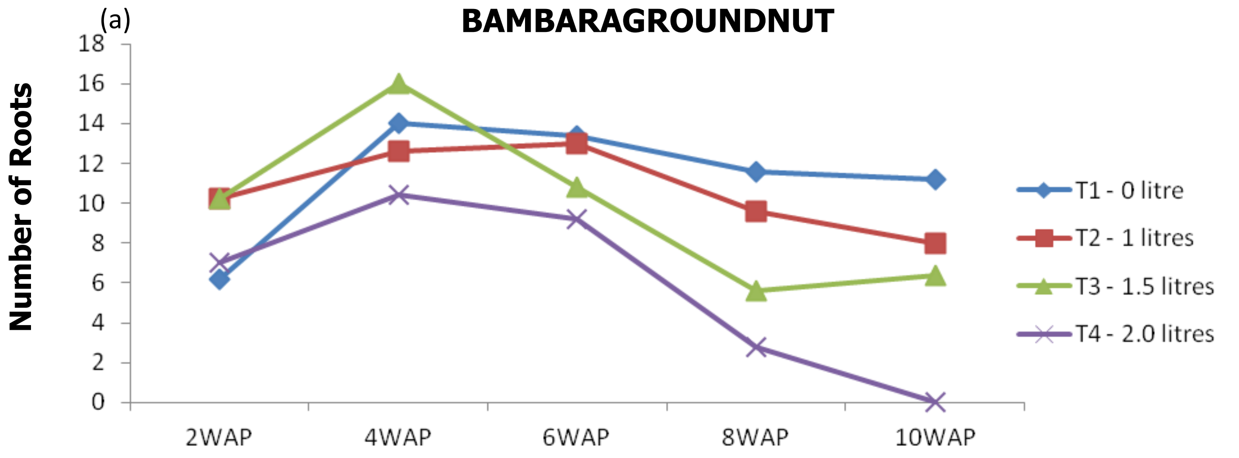
The treatment levels (0, 1.0, 1.5 and 2.0litre) were found to significantly influence the root dry weight of the test crops. The root dry weight was significantly reduced by 2.0 litres pollution level than observed in control and 1.0 litre pollution level. This could be due to reduction in the amount of synthate translocated from leaves to root region due to blockage of xylem by diesel oil hydrocarbon which limit absorption of nutrients (N, P, and K) necessary for synthesis of organic compounds. In addition, the reduction could be attributed to interference in the root metabolic pathway in phyloem and xylem structure due to anatomical and morphological abbrreiation caused by diesel oil pollution in the soil. This agreed with findings of Omosun *et al.* (2008).

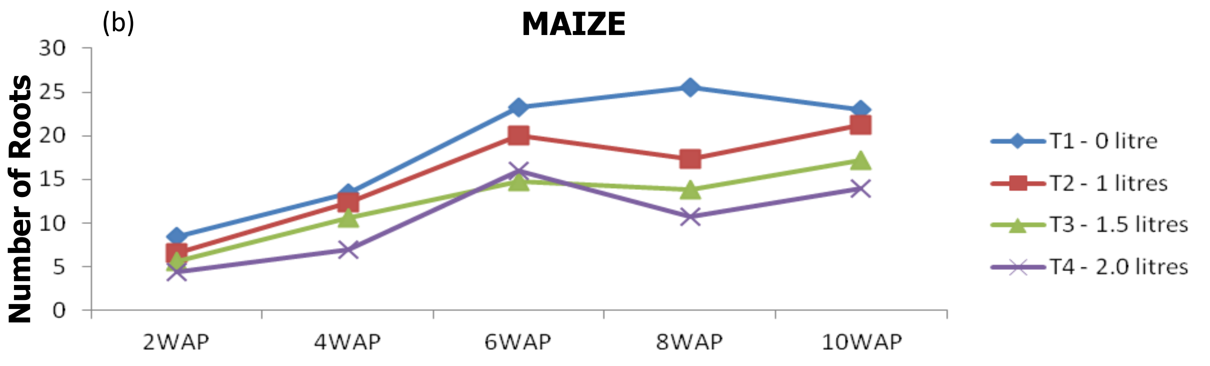
Effects of treatments showed that higher level of diesel oil application reduced the root dry weight. However, the degree of impact, is specie dependent (figure 3). This is because, the maize root irrespective of treatment levels recorded significantly higher root dry weight than others. On the other hand, 2.0 litres pollution level was found to affect heavily on soybean than in Bambaragroundnut and maize; although Bambaragroundnut could not withstand toxicity of high dose of diesel oil (2.0 litres) up till 10WAP which result in complete death of seedlings.

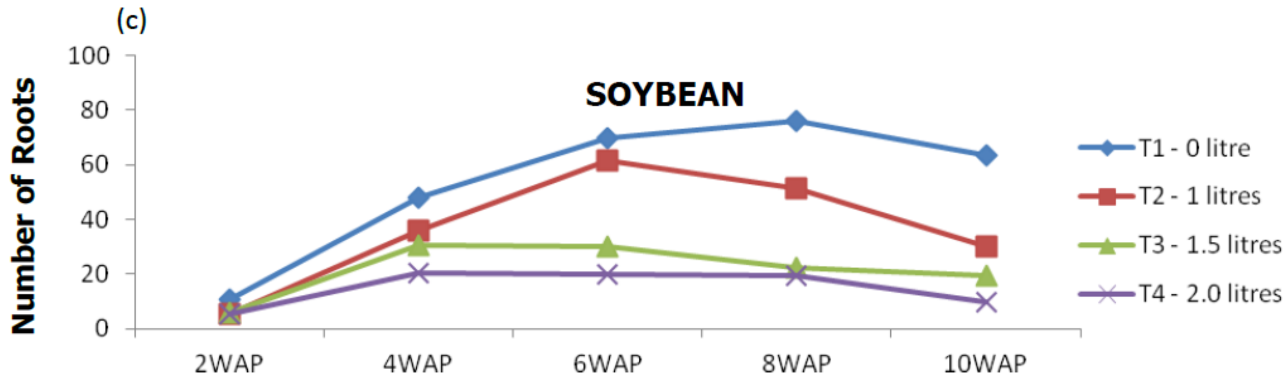
The growth parameters demonstrate an overall dose dependent response, although at lower concentration (1.0 litre) the plant species showed a positive response to the diesel oil contaminant. Also exposing the plant species to high diesel oil contamination caused a reduction in root dry weight resulted from coating of oil film in vascular bundles by diesel oil thereby affecting physiological functions within the roots.

In this study a significant stimulatory effect of diesel oil pollution on Relative growth rate of Soybean at relatively high diesel oil pollution level (2.0litres) was observed compared to that of Bambaragroundnut and Maize. Reason for enhanced growth may include and hormonally influenced stress response as suggested by Merk *et al.* 2004. Alternatively stress response by some plants facing nutrient limitation may also result in growth stimulation. Increased root biomass may also be strategy to stimulate water, Nitrogen or Phosphate uptake in the plant (Frick *et al.*, 1999).

Considering the role of roots in absorption of essential elements and anchoring of plants to the soil ,this study has shown that establishment of root growth parameters and subsequent growth of plants were affected physiologically by diesel oil pollution which manifested in morphological aberration of plants thereby reducing the yield of crop plants. This study has shown that diesel oil has deleterious effect on plants irrespective of species; hence it has become imperative for Government agencies in area prone to oil spillage to continue to mount awareness campaign in order to put an end to oil pollution.

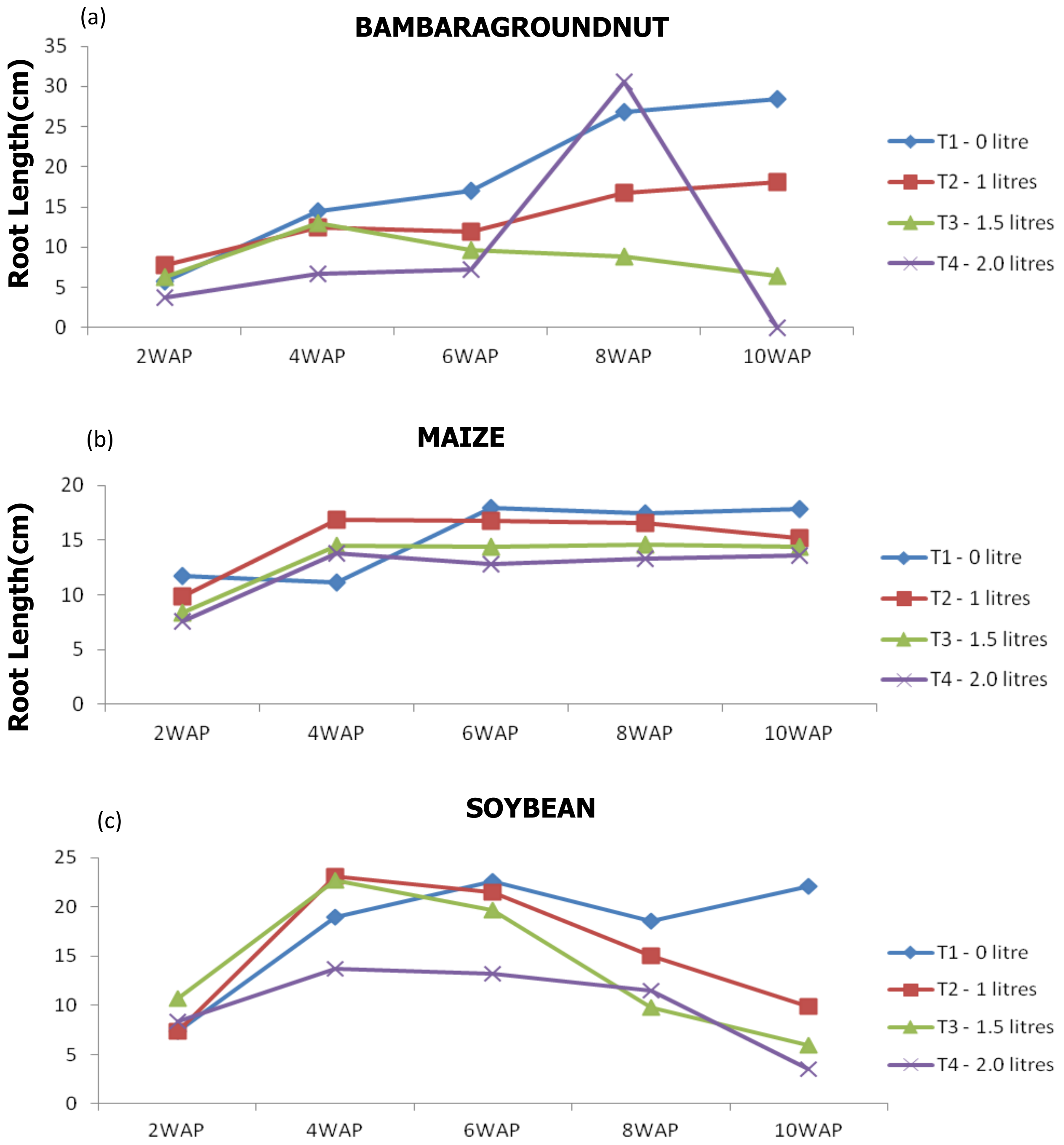






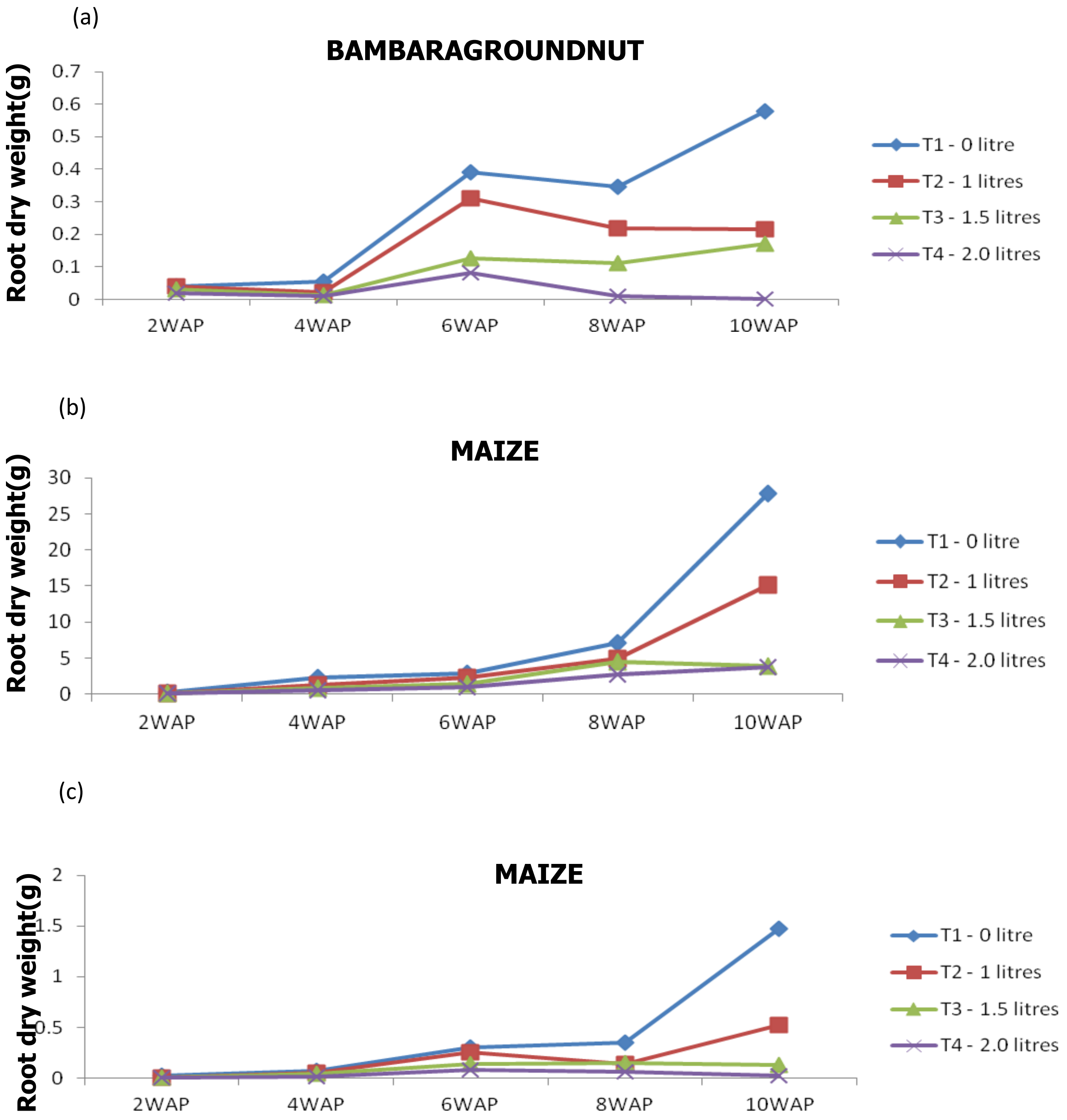
Weeks After Planting (WAP)

Fig. 1 (a, b and c): Number of Roots of Test crops as influenced by diesel oil pollution



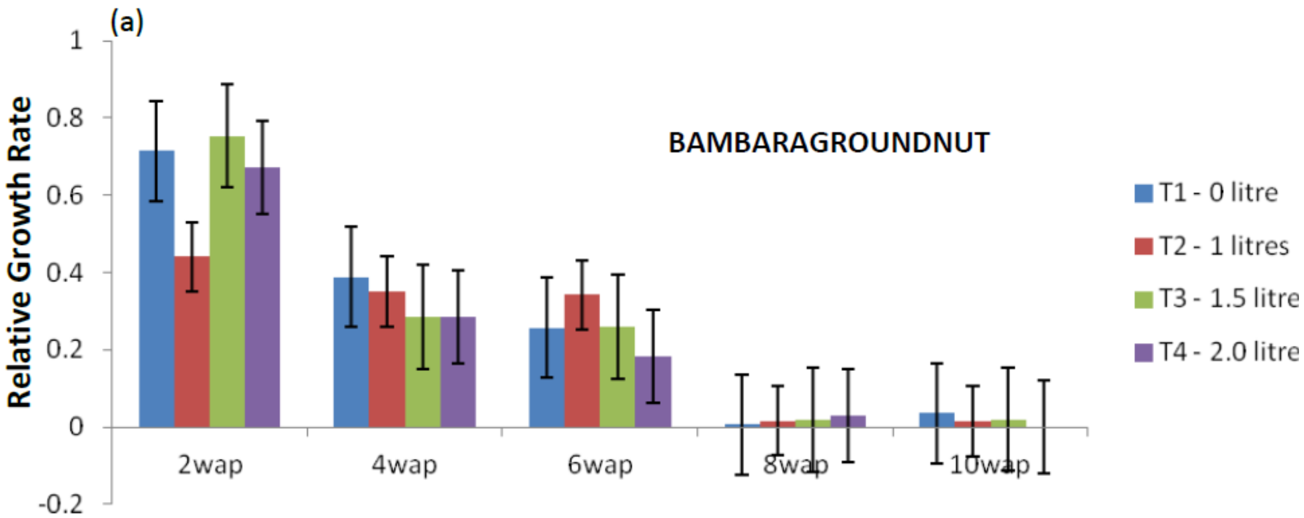
Weeks After Planting (WAP)

Fig. 2 (a, b and c): Root Length (cm) of Test crops as influenced by diesel oil pollution



Weeks After Planting(WAP)

Fig. 3 (a, b, and c): Root dry weight(g) of Test crops as influenced by diesel oil pollution



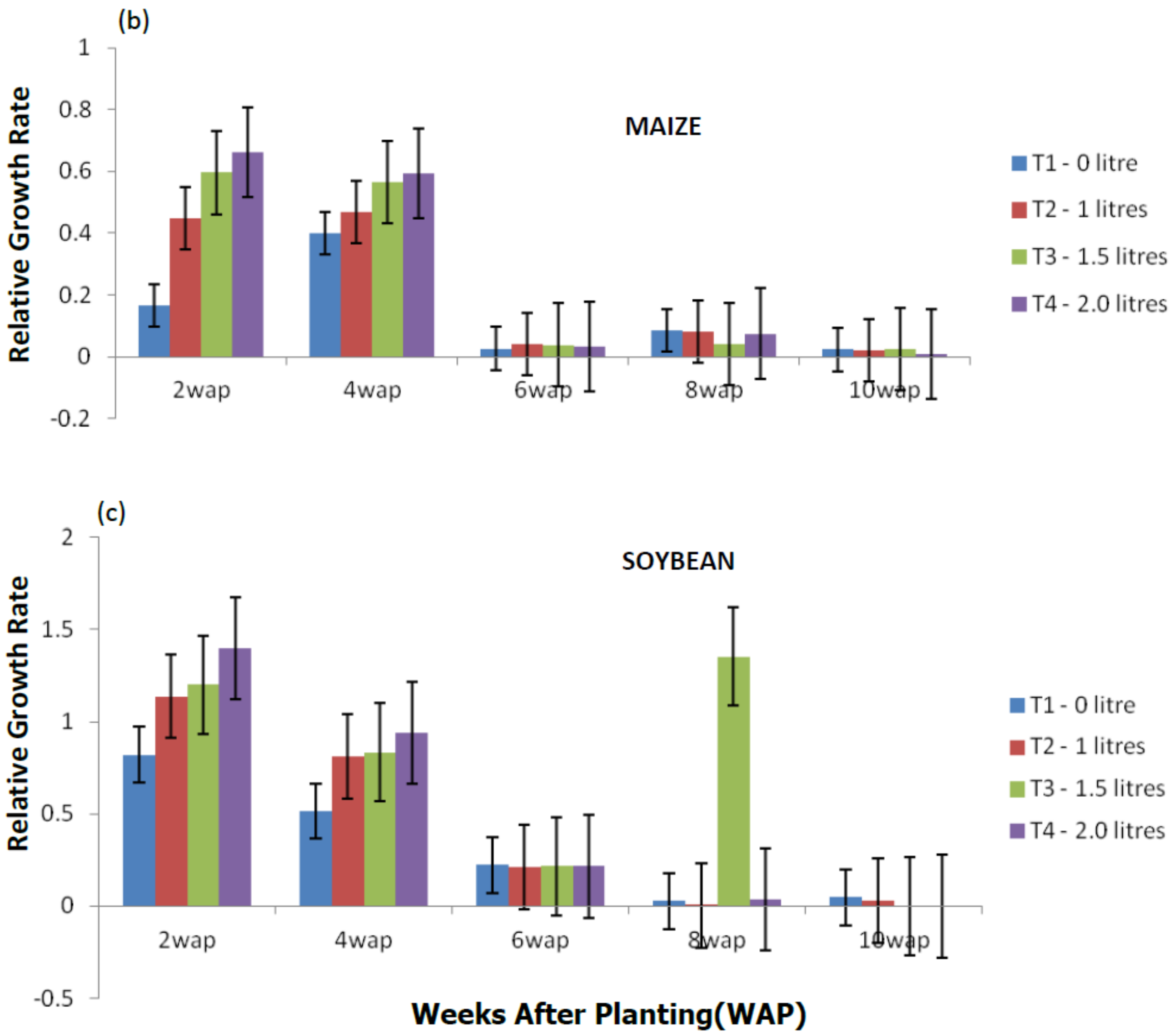


Fig. 4 (a, b, and c): Relative Growth Rate of Roots Test Crops as is Influenced by Diesel Oil Pollution

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