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Yield and Nutrient Depletion of Tomatoes by Radio-Frequency Radiation Exposure from Base Transceiver Stations in Ogbomoso, Nigeria

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Abstract

Major concerns are increasingly being raised about the effects of radiofrequency radiation (RFR) on different compartments of the biosphere. A major source of RFR currently being widespread is the base transmission station (BTS) of mobile telephone network, involving transceiver antenna. Soils inclusive of farmlands are likely being affected by the continuous exposure to RFR. The extent of soil depletion brought by RFR from BTS was assessed in this study.

The effects of RFR were determined from evaluation of hybridized tomatoes planted on soil collected at different distances away from the BTS under the same agro-climatic conditions. The variation noticed in the tomato yield of the exposed group at the nearest distance and the contents of magnesium and potassium of the exposed groups at all the distances were significantly different when compared with the control group. It is imperative from this study to state that significant effect of RFR from BTS was noticed in plant, thus suggesting that regulations be put in place to check the proliferation of BTS close to residential buildings.

Keywords: Radiofrequency radiation; Base transceiver stations; Tomato; Exposed group; Control group

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Introduction

Radio-Frequency Radiation (RFR) emanating from Base Transceiver Stations (BTS) has been reportedly capable of affecting plants, generally and mostly experimented are vegetables and food crops in the vicinity of the RFR [1-4]. Studies have shown definitive clues that cell phone electromagnetic field (EMF) can choke seeds, inhibit germination and root growth, thereby affecting the overall growth of plants [5-7]. A reduction in wheat and corn yield in the fields near high EMF lines was also reported [8].

Tree tops were noticed to have the tendency to dry up when they face the communication infrastructure antennas [9]. The browning of tops of tree is often observed near communication infrastructures, particularly when water is near their root base. During this exposure, the tree tops are reported to behave as RF waveguides [10]. The trees were also seen to have a gloomy and unhealthy appearance, possible growth delays, and a higher tendency to contract plagues and illnesses. Algae and other vegetation may also be affected by Radio-Frequency Electromagnetic Field (RF-EMF) [11]. Kumar and Kumar [12] discovered in a further study that the output of most fruit-bearing trees decreased out rightly from 100% to 5% after more than 910 days of communication infrastructure installation in a farm facing four communication infrastructures in Gurgaon–Delhi Toll Naka, India.

A finite possibility exists that various effects noticed in plants could be traceable to the effect of RFR exposure on soils from where nutrients required by plants are derived.

Materials and Methods

Measurement of power density in the vicinity of base transceiver stations

In this work, the method of broad-band analysis was employed in the measurements. A hand held Electrosmog meter by TES Electrical Electronic Corporation USA (model TES-92) was used in the Radio-Frequency (RF) survey. It measures the value of the electric field and converts it into the magnetic field and the power density [13]. Measurements were made by simply pointing the meter to the source of the RF radiation.

Plant investigation

Hybridized seed of tomato was sown in nursery beds before being transplanted to the experimental bowls. Soil samples collected from a base transceiver station (BTS) located at Ladanu village, Ajaawa Local Government, Ogbomoso, Nigeria. Soil used as control was collected from a location reported to have close to zero level of radio frequency radiation, which is about 5 km to the nearest BTS (**Table 1**). Equal mass of the soil samples were collected from distances of 25 m, 50 m, 75 m and 100 m from the BTS and put in identical perforated bowls. The distance of soil collection from the BTS was marked on each pots. Each distance had three replicates (rep 1, rep 2 and rep 3). The tomatoes nursery was established on a homogeneous soil. The tomatoes seedlings from the nursery was transplanted into the marked potted soil and thereafter transferred to the already prepared field for eight weeks.

The potted seedlings were nurtured to maturity under named agro-climatic conditions. The tomato yield, magnesium and potassium contents of the soils were determined. The proximate analysis of the harvested tomato fruits was also carried out.

Statistical analysis

The results obtained in this work were expressed in mean ± standard error (S.E.). Tests of significance were carried out using analysis of variance. A post-hoc test of significance was carried out using Dunnett's multiple range test. These tests of significance were done on Graphpad Prism package version 5 for windows using the level of significance (α)<0.05.

Proximate analysis

This refers to the determination of the major constituents of tomato and it is used to assess if tomato is within its normal compositional parameters or somehow been adulterated. This method partitioned nutrients in tomato into 5 components: crude protein, crude fibre, ether extract, ash and moisture. The proximate analysis was carried out at Institute of Agricultural Research and Training (IAR & T), Ibadan, Nigeria.

The crude protein content of the tomato samples was determined using the Microkjeldahl method of AOAC [14]. The crude fibre was determined in the sample using the standard methods of analysis of the AOAC. The crude fat was determined using Soxhlet extraction method of AOAC. The ash content was determined using the method reported in the handbook of AOAC. The moisture content was determined using the oven method described by standard official methods of analysis of the AOAC.

Results and Discussion

The effects of RFR exposure from Base Transceiver Stations (BTS) on tomato yield, magnesium and potassium contents and proximate analysis were presented in **Tables 2 and 3**. The effects of RFR exposure on the tomato yield showed the variation between the exposed groups and the control as presented in **Table 2**. At certain distances, the tomato yield, magnesium and potassium contents followed specific patterns. The tomato yield for the exposed group increased with distance from 25 m to 100 m, the magnesium content for the exposed group increased with distance from 25 m to 75 m while the potassium content for the exposed group decreased with distance from 50 m to 100 m. Generally, the least yield, magnesium and potassium contents were observed at the least distance (25 m).

The tomato for the exposed group showed the highest yield (10.00 ± 0.20 mg/pot) at distance 100 m, followed by 6.50 ± 0.10 mg/pot at distance 75 m, followed by 6.00 ± 1.70 mg/pot at distance

Table 1 Location for each group of Base Transceiver Stations (BTS).

Group	Location	Geo-coordinate	Radio-Frequency Radiation Level (μW/m²)	Motivations for choice of location for each group
Control	Prison area, Ogbomoso, Nigeria	Lat. 8.1162° N, Long. 4.2452° E	0.0-0.1	Yet to be commissioned
Exposed	Ladanu village, Ajaawa local government, Ogbomoso, Nigeria	Lat. 7.5516° N, Long. 4.0948° E	0.2-34.2	The BTS is very close to residential building

Table 2 Effect of distance from Base Transceiver Station on Tomato yield, Magnesium and Potassium contents.

Treatment	++++Yield (mg/p°t)	+++Mg Content (mg/l)	mmmK Content (mg/l)
Tomato (Control)	7.60 ± 0.30	46.51 ± 0.02	9.59 ± 0.01
Tomato (25 m)	3.50 ± 0.10*	46.63 ± 0.01*	10.74 ± 0.02*
Tomato (50 m)	6.00 ± 1.70	47.21 ± 0.01*	12.58 ± 0.01*
Tomato (75 m)	6.50 ± 0.10	47.29 ± 0.02*	12.14 ± 0.02*
Tomato (100 m)	10.00 ± 0.20	47.03 ± 0.01*	12.01 ± 0.01*

* indicates significant difference at α<0.05

+++ indicates specific patterns (increase) for the exposed tomato between 25 m and 75 m

++++ indicates specific patterns (increase) for the exposed tomato between 25 m and 100 m

mmm indicates specific patterns (decrease) for the exposed tomato between 50 m and 100 m.

Table 3 Effect of distance from base transceiver station on proximate analysis of harvested tomato.

Treatment	Crude Protein (%)	Crude Fibre	++++Ether Extraction (%)	mmmAsh	++++Moisture (%)
Tomato (Control)	7.53 ± 0.01	10.42 ± 0.01	8.24 ± 0.01	8.48 ± 0.01	14.15 ± 0.01
Tomato (25 m)	10.88 ± 0.01*	10.05 ± 0.01*	6.44 ± 0.01*	8.04 ± 0.01*	9.22 ± 0.01*
Tomato (50 m)	10.83 ± 0.01*	14.21 ± 0.01*	7.72 ± 0.01*	8.31 ± 0.01*	9.42 ± 0.01*
Tomato (75 m)	8.75 ± 0.01*	13.15 ± 0.01*	8.15 ± 0.01*	7.29 ± 0.01*	12.66 ± 0.01*
Tomato (100 m)	10.06 ± 0.01*	13.21 ± 0.01*	8.62 ± 0.01*	3.28 ± 0.01*	13.65 ± 0.01*

*indicates significant difference at $\alpha<0.05$
++++ indicates specific patterns (increase) for the exposed tomato between 25 m and 100 m
mmm indicates specific patterns (decrease) for the exposed tomato between 50 m and 100 m.

50 m while the least yield (3.50 ± 0.10 mg/pot) was observed at distance 25 m. The variation noticed in the tomato yield of the exposed group at 25 m was significantly different at p<0.05 when compared with the yield of the control group at same 25 m. Yield of the control tomato was observed to be higher than each of the exposed tomato at distance less than 100 m. However, the tomato yield did not significantly differ at distances from 50 m to 100 m in comparison with the value of control tomato. The result from **Table 2** therefore indicated that tomato should be planted above 25 m distance from base transceiver stations.

Similarly, the tomato for the exposed group showed the highest magnesium content (47.29 ± 0.02 mg/l) at distance 75 m, followed by 47.21 ± 0.01 mg/l at distance 50 m, followed by 47.03 ± 0.01 mg/l at distance 100 m while the least magnesium content (46.63 ± 0.10 mg/l) was observed at distance 25 m. Magnesium content of the control tomato was observed to be lower than each of the exposed tomato. The variation noticed in the tomato magnesium content of the exposed group at 25 m to 100 m were significantly different at p<0.05 when compared with the magnesium content of the control group.

Conversely, the tomato for the exposed group showed the highest potassium content (12.58 ± 0.01 mg/l) at distance 50 m, followed by 12.14 ± 0.02 mg/l at distance 75 m, followed by 12.01 ± 0.01 mg/l at distance 100 m while the least potassium content (10.74 ± 0.02 mg/l) was observed at distance 25 m. Potassium content of the control tomato was observed to be lower than each of the exposed tomato. The variation noticed in the tomato potassium content of the exposed group at 25 m to 100 m were significantly different at p<0.05 when compared with the potassium content of the control group.

The effects of RFR exposure on the proximate analysis (crude protein, crude fibre, ether extraction, ash and moisture) showed the variation between the exposed groups and the control as presented in **Table 3**. Ether extraction and moisture for the exposed distances followed a specific pattern. As the distance increased, ether extraction and moisture were observed to increase. Crude protein, crude fibre and ash for the exposed group did not follow a specific pattern.

The tomato for the exposed group showed the highest ether extraction (8.62 ± 0.01%) at distance 100 m, followed by 8.15 ± 0.01% at distance 75 m, followed by 7.72 ± 0.01% at distance 50 m while the least ether extraction (6.44 ± 0.01%) was observed at distance 25 m. Ether extraction of the control tomato was observed to be lower than each of the exposed tomato at distance less than 100 m. The variation noticed in the tomato ether extraction of the exposed group at 25 m to 100 m were significantly different at p<0.05 when compared with the ether extraction of the control group.

The tomato for the exposed group showed the highest moisture (13.65 ± 0.01%) at distance 100 m, followed by 12.66 ± 0.01% at distance 75 m, followed by 9.42 ± 0.01% at distance 50 m while the least moisture (9.22 ± 0.01%) was observed at distance 25 m. Moisture of the control tomato was observed to be lower than each of the exposed tomato. The variation noticed in the tomato moisture of the exposed group at 25 m to 100 m were significantly different at p<0.05 when compared with the moisture of the control group.

The tomato for the exposed group showed the highest crude protein (10.88 ± 0.01%) at distance 25 m, followed by 10.83 ± 0.01% at distance 50 m, followed by 10.06 ± 0.01% at distance 100 m while the least crude protein (8.75 ± 0.01%) was observed at distance 75 m. Crude protein of the control tomato was observed to be lower than each of the exposed tomato. The variation noticed in the tomato crude protein of the exposed group at 25 m to 100 m were significantly different at p<0.05 when compared with the crude protein of the control group.

The tomato for the exposed group showed the highest crude fibre (14.21 ± 0.01%) at distance 50 m, followed by 13.21 ± 0.01% at distance 100 m, followed by 13.15 ± 0.01% at distance 75 m while the least crude fibre (10.05 ± 0.01%) was observed at distance 25 m. Crude fibre of the control tomato was observed to be lower than each of the exposed tomato above 25 m. The variation noticed in the tomato crude protein of the exposed group at 25 m to 100 m were significantly different at p<0.05 when compared with the crude protein of the control group.

The tomato for the exposed group showed the highest ash (8.31 ± 0.01%) at distance 50 m, followed by 8.04 ± 0.01% at distance 25 m, followed by 7.29 ± 0.01% at distance 75 m while the least ash (3.28 ± 0.01%) was observed at distance 100 m. Ash of the control tomato was observed to be above each of the exposed tomato. The variation noticed in the tomato ash of the exposed group at 25 m to 100 m were significantly different at p<0.05 when compared with the ash of the control group.

The least crude fibre, ether extraction and moisture were observed at the least distance (25 m). All the proximate analysis parameters were significantly ($\alpha<0.05$) different at all the exposed distances. This work corroborated the findings of Soja *et et al.,* [8]; Max, [1]; Tkalec *et al.*, [5] and Ayhan *et al.,* [6]; Waldmann-Selsam *et al.*, [7].

Conclusion

The exposed tomato yield followed a specific pattern. The yield of exposed tomato was lowest at the closest distance to the BTS. Furthermore, the magnesium and potassium contents of the exposed group at all the distances showed significant difference when compared with the control. The least yield, magnesium and potassium contents, crude fibre, ether extraction and moisture were observed at the least distance (25 m). It is imperative from this study to state that significant effect of RFR from BTS was noticed in plant, thus suggesting that regulations be put in place to check the proliferation of BTS close to residential buildings as well as soil impact assessment before mobile telephony infrastructure is installed.

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