Radionuclides Analysis of Some Soils and Food Crops in Barkin Ladi LGA ,Plateau State-Nigeria

D.I. Jwanbot[1*],M.M.Izam[2], G.G.Nyam[3] and H.N.John[4]
1,2&4. Department of Physics University of Jos-Nigeria
3 Department of Physics University of Abuja-Nigeria
*E- mail of corresponding author: jwanbot2009@yahoo.com

Abstract
The investigation is aimed at establishing the activity concentrations in some farmland soils and crops across Barkin Ladi LGA. The activity concentrations of twenty (20) soil samples and twenty (20) food crop samples from the farmlands were determined using a multi-channel pulse-height analyzer (Camberra series 10 plus) coupled to a 76mm x 76mm NaI (Tl) scintillation detector. The activity concentration for ^{40}K, ^{226}Ra and ^{232}Th from the soil samples ranged from (144.30 ± 5.59) Bq/Kg to (282.58 ±4.82) Bq/Kg, (12.05 ± 9.73) Bq/Kg to (101.83 ± 1.85) Bq/Kg and (35.92 ± 1.71) Bq/Kg to (83.55± 3.62) Bq/Kg respectively. Hence the mean concentration obtained for each radionuclide is 218.93Bq/Kg for ^{40}K, 39.61Bq/Kg for ^{226}Ra and 58.90 Bq/Kg for ^{232}Th. This showed that these values are above the mean annual standards of 25 Bq/Kg and 25 Bq/Kg for ^{226}Ra and ^{232}Th except for ^{40}K which is lower than the mean annual value of 370Bq/Kg. The activity concentrations measured from most of the soil suggest that crops grown on these farms exhibit similar measurement because most crops have high intake from their roots. The activity concentration for ^{40}K, ^{226}Ra and ^{232}Th in the crops ranged from (41.59 ± 0.67) Bq/Kg to (198.26 ± 7.46) Bq/Kg, (12.05 ± 9.73) Bq/kg to (75.69 ± 3.71) Bq/Kg and (38.28 ± 1.82) Bq/kg to (89.28 ± 2.17) Bq/Kg, with mean values which stands at (114.75 ± 4.99) Bq/Kg for ^{40}K, (42.41 ± 4.67) Bq/Kg for ^{226}Ra and (62.01 ± 1.37) Bq/Kg for ^{232}Th respectively. Hence the results obtained in this study indicate that the activity concentration of the farmland soils and crops represent a significant health risk on the farmers and the consumers of the crops.
Keyword: Activity concentration, soil, food crops, Gamma ray spectrometry and Radionuclides

Introduction

The natural terrestrial gamma radiation dose rate is an important contribution to the average dose rate received by world's population. Estimation of the radiation dose distribution is important in assessing the health risk to a population and serve as the reference in documenting changes to environmental radioactivity in soil due to anthropogenic activities. Human being is exposed out doors to terrestrial radiation that originate predominantly from the upper 30cm of the soil. Only radioactive elements with half-lives comparable with the age of the earth or their corresponding decay products existing in terrestrial material such as ^{232}Th, ^{238}U, and ^{40}K, are of great interest in this study. Since this radioactive elements are not evenly distributed in soils, rocks, and plant crops, hence its play an important role in radiation protection and measurement (Farai, 1989).

Acknowledged by Ibeanu, 2003 tin ore is a radioactive mineral, which is rich in monazite and zircon components. During the tin ore processing operations, Uranium and thorium concentrate are responsible for the observed high concentrations level measured in the tailing dump and contaminated soil, rocks, streams, farm lands which are extended to the crops grown at the farms. Mining activities generally have a high impact on man and environment. This partially results to an increase in employment and economic profit for the community and the operators but also represent a threat to natural reserves due to landscape changes and pollution. This often results in destroyed ecosystem and polluted environment, which represents a hazard to the local population. Processing by-product heavy minerals from tin mining areas is rich in Uranium and thorium and external exposures occurs when workers or persons are close to stock piles of radioactive materials, soils and tailings (Ibeanu, 2003). Geologically, the lithological formations of the Jos-Plateau, Nigeria, consist of basement complex, biotite granites and new basalt. Occurrence of tin and columbite-ore found in this area is usually associated with greisenised biotite granite, and their abundance led to the mining and exploration activities in the area that commenced since 1904 that lasted for about five decades (Jibiri, 2007).

The tailings were treated as non-radioactive and as such were used for building construction, farming and industrial activities. During the mining of the Sn-Ore to obtain tin, columbite, monazite, zircon and ilmenite are also generated and the methods of processing include: electrostatic, magnetic separation and manual processing methods. These methods produce radioactive elements, which was widely dispersed into the environment. This has left a legacy of polluted water supplies, improvised agricultural land and soil containing abnormally high

levels of naturally occurring radioactive elements with interactions of ionizing radiation in the environment. This leads to various biological effects that may later show up as a clinical symptom. The nature and severity of the symptoms depends on the absorbed dose as well as the rate of many sickness and diseases which have been effectively managed if information about the radiation level of an environment is available.
Barkin- Ladi LGA is located longitude $008^0 50'22.1''$ – $008^0 58'22.2''$ and latitude $09^0 25'08.1''$ – $09^0 42'48.2''$ on a granite Plateau of about 1440m above sea level in Plateau State in the North Central part of the country (Figure 1). The lithological formations in the area are composed of basement complex biotite granite and new basalts. Tin and columbite ore are associated with greisenized, Biotite granites.

The aim of this work is to assess the radioactivity level in farmland soils and crops in some selected villages in Barkin Ladi LGA of Plateau State, Nigeria. For the purpose of this study ten (10) villages were selected and in each village two (2) farmland soils and crop samples were collected in each village. Gamma-ray spectroscopy was used to determine the gamma-ray activities of the radionuclides.

MATERIALS AND METHOD

A total of 20 surface soil samples of natural origin were collected from the 20 different locations at the same depth level of 0 to 6cm around Barkin Ladi LGA. The samples were collected from 10 villages with two sample collected from a village at $1km^2$ square apart and these points of collection were marked out using (GPS). Samples obtained by clearing the surface vegetation and removing dead organic matter from the surface of the location and then taking a core sample from it from a depth of 6cm(Jibiri *et al*,2007) sample weight varied from 1.0 to 1.5kg.
At a collection point the soil sample was wrapped in black plastic bag and then taken to the laboratory. All soil samples were individually allowed to dry for 72 hours under laboratory temperature of about 27^0C and relative humidity of about 70 %(IAEA, 1989). Each dried soil samples was ground and sieved using a 2mm mesh screen. The large particles were disposed off and the meshed soil sample were stored in plastic containers for four weeks to allow time for secular equilibrium for ^{238}U and its corresponding progenies (Ajayi and Ajayi,1999). The plastic container of fixed geometry used was ensured air-tight by using an epoxiglue to seal samples.
About 100g each of meshed soil sample was then transferred to a $100cm^3$ capacity aluminum container and analyzed for gamma activity immediately.
The gamma-ray analysis was done on a very sensitive gamma spectroscopic system which consists of a 76.2cm x 76.2cm NaI (TI) scintillation detector coupled to a Camberra series 10 plus multichannel analyzer (MCA). The detector has a resolution of about 7.4% at the 662kev line for ^{137}Cs which is good enough for distinguishing gamma-ray energies of the radionuclide being measure . The detector was placed in a 5cm thick lead shield to reduce the effects of natural background radiation(Myrick,1983).
The gamma ray spectrometry located at Centre for Energy Research and Training ABU Zaria was used in determination of activity concentration of the uranium of the radionuclides in soil and food samples. The soil samples were mounted on the surface of the scintillation detector and each counted for 21600 seconds in reproducible sample detector geometry. A computer based multichannel analyzer system with an ACCUSPEC programme (Model 2007p) was used for the data acquisition analysis of gamma spectra. The gamma transition energy of 1765kev (due to ^{214}Bi) was used to determine the concentration of ^{238}U in the soil sample.

RESULTS AND DISCUSSION

Table 1 shows the results of the gamma-ray analysis for the natural radionuclides of ^{40}K, ^{226}Ra and ^{232}Th concentration values and their average in the 20 soil samples. The location value of ^{40}K concentration in the soil was found to vary from (114.3 ± 5.597) Bq/kg in location S_6 to (282.58 ± 4.8212) Bq/kg at location S_7 for ^{226}Ra the location value ranged from (10.5424 ± 2.6182Bq/kg to (101.83 ± 1.8536) Bq/kg in location S_3 and S_{10} respectively. The mean concentration C_K, C_{Ra} and C_{Th} for ^{40}K, ^{226}Ra and ^{232}Th in Barkin Ladi were 218.93 ± 8.12)Bq/kg 39.61 ± 2.9301Bg/kg and 58.902 ± 1.872Bq/kg respectively

Table 2 shows the results of gamma-ray analysis for the natural radioactive elements ^{40}K, ^{226}Ra and ^{232}Th concentration values, their average in 20 crop samples, collected from different farms across Barkin Ladi LGA. The concentrations of ^{40}K vary from 41.595 ±0.6702 Bq/kg to 198.26 ± 7.46 Bq/kg which are yam (*Dioscorea rotundata*) and cabbage (*Brassicca oleracea*) for ^{226}Ra the concentration ranged from 12.04 ± 9.70 Bq/kg to 75.69 ± 3.70 Bq/kg which are green beans (*Pisum sativum*) the concentration values for ^{232}Th vary from 38.28 ± 89 to 282 ± 2.1665 Bq/kg and the crops are cabbage (*Brassicca oleracea*) and green beans (*Pisum sativum*)

respectively. The mean concentration $C_{K,}$ C_{Ra} and C_{Th} for ^{40}K, ^{226}Ra and ^{232}Th in the farmland soils are 114.756 ± 4.9919 Bq/kg, 42.4197 ± 4.6719 Bq/kg and 62.7091 ± 1.36 Bq/kg respectively.
The activity concentration of the twenty (20) soil samples for ^{40}K, ^{226}Ra and ^{232}Th range from 144.3 ±5.59 Bq/kg to 282.58 ± 4.82Bq/kg, 14.73 ± 4.58Bq/kg to 101.83 ± 1.85Bq/kg and 35.91 ± 1.71 Bq/kg to 83.54 ± 2.62 Bq/kg with mean values of 218.93 ± 8.12Bq/kg 39.61 ± 2.93 Bq/kg and 58.90 ± 1.87 Bq/kg respectively. The soil activities concentrations in the study area are not the same, but observed significant different in some cases. The asymmetric distribution exhibited by the soil is due to the high variability in the activity concentration level of the soil samples which is as a result of the significant difference in activity of the farmland soils in the study area such as, type of soil, soils formation, soil transport process and application of fertilizer in the farmlands which can effect a change on the activity concentration in the soil (Jwanbot *et al*, 2012).
The activity concentrations for the twenty (20) crop samples for ^{40}K, ^{226}Ra and ^{232}Th ranged from 41.595 ± 0.6702 Bq/kg to 198.26 ± 7.46, 12.048 ± 9.7312 to 75.69 ± 3.24 and 38.28 ± 1.82 to 89.28 ± 2.1665 Bq/kg respectively. Hence the result shows that crops are predominant absorber of ^{40}K than ^{226}Ra and ^{232}Th radionuclides (Jwanbot *et al,* 2012). This is because potassium is an essential element and plant isotopic differentiation, thus ^{40}K is preferred to the other two radionuclides. Cabbage (*Brassica*) absorbed the highest amount of ^{40}K concentration of (198.28 ± 7.46) Bq/kg at C_{10} and (144. ± 5.59) Bq/kg at C_{14} respectively.
Cocoyam (*Colocasis exculenta*) also recorded a high ^{40}K concentration at C16 with a value of (136.84 ± 4.19)Bq/kg there are observable trend in the activity concentration of the crops with ^{40}K having the highest concentration and ^{232}Th having a higher activity concentration than ^{226}Ra. This may be attributed to the poor migration of characteristics of radium from the substrate to the vegetable in the study area. Hence this variation may be explained on the basis that these crops were not collected from same farmlands and a slight modification in factors like physio-chemical characteristics and pH of the soil in which the plant grown may lead to variability in concentration of the radionuclide in some food crops or among different food crops within the study area.

Conclusion

From the results it can be concluded that ^{40}K is the most predominant radionuclide in soil land crop samples. The activity concentration of ^{40}K in the soil samples collected from the study area shows that ^{40}K is twice more in the soil than in the crop samples, when taking the mean values of 218.93Bq/kg for soil and 114.75Bq/kg for crops into consideration. The high activity concentration of ^{40}K in some soil samples located all point necessitate an increase in the concentration of the crops grown on these farms. The activity concentrations of ^{226}Ra and ^{232}Th in crops and soil samples do not have much variation when considering their corresponding mean values.

References

Ajayi I.R (1994): Radionuclides Analysis of Soils and Sediments in Ondo State, Southwestern,Unpublished Ph.D Thesis, Dept. of Physics, University of Ibadan, Nigeria.
Ajayi I.R and Ajayi O.S (1999): Estimation of absorbed dose rate and collective effective dose equivalent due to gamma radiation from selected radionuclides in soils in Ondo and Ekiti States SW Nigeria. *Radiat Prot Dosim*, **86**; 221.
Farai I.P (1989): Rn-222 Survey in ground water and its assessments for radiological health hazards and seismic monitoring in Nigeria. Ph.D Thesis, University of Ibadan, Ibadan, Nigeria.
IAEA (1989): Measurement of Radionuclide's in Food and the Environment. International Atomic Energy Agency, Technical Report Series No. 295, Vienna.
Ibeanu I G. E (2003): Tin mining and processing in Nigeria: Cause for concern **64,** 59-66
Jibiri N. N(2001): "Assessment of Health Risk Levels Associated with Terrestrial Gamma Radiation Dose Rate in Nigeria", *Internat,* **27**,.21-26
Jibiri N. N, Farai.P, Alausa S.K (2007): Estimation of an annual effective dose due to natural radioactive elements in ingested foodstuff in tin mining area of Jos-Plateau-Nigeria. *J. Environ Radioactivity*, **94;** 31-40.
Jwanbot ,D.I.,Izam,M.M.and Nyam,G.G (2012):Radioactivity in some food crops from high background radiation area on the Jos-Plateau, Nigeria. *Journal of Natural Science Research* **2**(6),76-78
Myrick T.E, Berven A.A, Haywood F.F (1983): Determination of Concentrations of Selected Radionuclides in Surface Soils in the US *Health Phys*, **45**: 631.

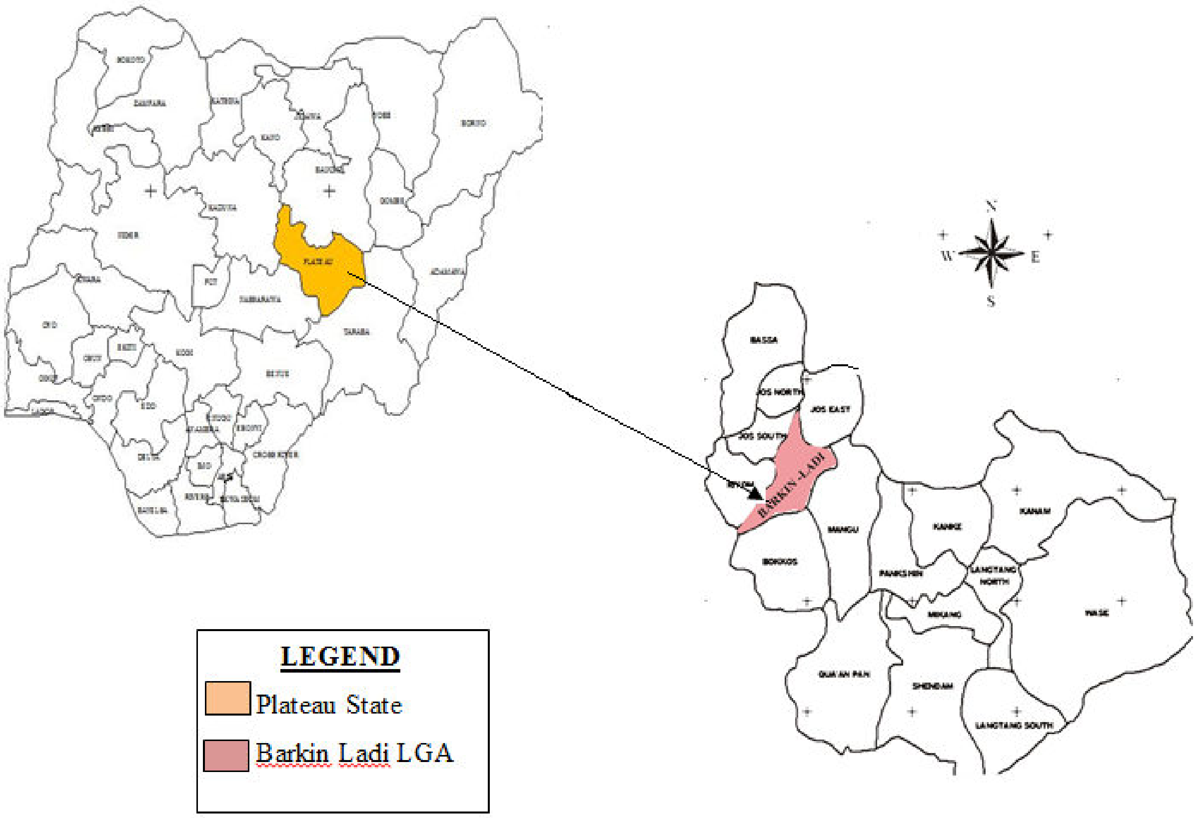

Fig 1: The map of Nigeria showing Barkin Ladi LGA.

Table1: Activity Concentration Levels of the Soil Samples from the Study Area

Soil Sample	Sample Location	Longitude	Latitude^{40}K	Bq/kg^{226}Ra	Bq/kg^{232}	Th Bq/kg
S1	Barkin Ladi A	008^0 54' 11.3"	09^0, 32' 38.0"	212.56 ± 3.903	34.071 ± 3.5913	74.703 ± 1.8248
S2	Barkin Ladi B	008^0 54' 03.2"	09^0, 32' 7.7"	257.19 ± 9.1743	71.36 ± 3.823	78.353 ± 1.8248
S3	Bisichi A	008^0 54' 23.7"	09^0, 42' 48.2"	252.53 ± 13.217	10.5424 ± 2.6182	64.553 ± 1.859
S4	Bisichi B	008^0 54' 40.8"	09^0, 42' 28.4"	210.56 ± 3.902	32.072 ± 2.5921	75.713 ± 1.731
S5	Fan A	008^0 58' 22.2"	09^0, 07' 31.2"	227.65 ± 10.25	46.177 ± 4.6339	58.14 ± 3.3645
S6	Fan B	008^0 58' 19.5"	09^0, 07' 46.9"	144.3 ± 5.5979	23.865 ± 2.6645	47.787 ± 0.7527
S7	Foron A	008^0 56' 40.7"	09^0, 39' 55.7"	282.58 ± 4.8212	28.151 ± 0.3823	67.503 ± 1.7104

S8	Foron B	008^0 55' 13.8"	09^0, 41' 46.8"	179.16 ± 0.9331	30.243 ± 1.6222	35.918 ± 1.7104
S9	Gassa A	008^0 54' 11.8"	09^0, 35' 02.1"	221.25 ± 11.211	44.254 ± 3.4754	81.547 ± 2.6232
S10	Gassa B	008^0 54' 07.0"	09^0, 34' 56.3"	274.34 ± 3.4215	99.629 ± 1.0429	44.367 ± 0.7982
S11	Gindin - Akwati A	008^0 50' 12.3"	09^0, 28' 48.5"	185.97 ± 12.129	101.83 ± 1.8536	59.421 ± 1.1405
S12	Gindin - Akwati B	008^0 50' 15.9"	09^0, 28' 36.8"	214.9 ± 8.0858	49.699 ± 3.2437	50.411 ± 1.2546
S13	Kassa A	008^0 53' 44.9"	09^0, 35' 45.2"	181.31 ± 8.7078	26.066 ± 3.4754	47.331 ± 1.5976
S14	Kassa B	008^0 50' 36.2"	09^0, 35' 44.6"	218.93 ± 7.484	40.325 ± 3.1256	45.311 ± 1.1541
S15	Kuru- Jenta A	008^0 50' 22.1"	09^0, 41' 24.7"	212.25 ± 10.211	46.254 ± 3.4754	71.547 ± 2.6232
S16	Kuru- Jenta B	008^0 52' 52.7"	09^0, 40' 49.8"	243.39 ± 10.731	18.93 ± 3.1279	83.714 ± 2.3951
S17	Rakwok A	008^0 53' 07.4"	09^0, 28' 28.8"	199.81 ± 12.585	14.736 ± 4.5876	52.692 ± 2.0529
S18	Rakwok B	008^0 53' 09.9"	09^0, 28' 39.7"	198.26 ± 7.4638	95.69 ± 3.7071	46.419 ± 0.9238
S19	Tenti A	008^0 55' 17.0"	09^0, 27' 57.4"	234.06 ± 4.5101	20.042 ± 0.1158	40.479 ± 2.7356
S20	Tenti B	008^0 55' 23.2"	09^0, 25' 08.1"	227.65 ± 14.15	48.077 ± 4.6339	57.14 ± 3.3645
Mean				**218.93 ± 8.12**	**39.61 ± 2.9301**	**58.902**

Table2: Activity Concentration Levels of the Food Crops Samples from the Study Area

Sample I.D.	Sample Location	Crop Sample	Longitude	Latitude	^{40}KBq/kg	^{226}RaBq/kg	^{232}ThBq/kg
C1	Barkin Lad A	Cabbage	008^0 54' 11.3"	09^0, 32' 38.0"	125.17 ± 6.2199	44.486 ± 1.4018	76.414 ± 1.0265
C2	Barkin Ladi B	Garden egg	008^0 54' 03.2"	09^0, 32' 7.7"	120.19 ± 7.1753	61.361 ± 2.824	78.353 ± 1.8704
C3	Bisichi A	Tomatoes	008^0 54' 23.7"	09^0, 42' 48.2"	130.31 ± 4.6649	36.376 ± 1.6219	52.692 ± 1.7336
C4	Bisichi B	Cabbage	008^0 54' 40.8"	09^0, 42' 28.4"	90.824 ± 6.9984	27.572 ± 1.9694	67.503 ± 1.7104
C5	Fan A	Cabbage	008^0 58' 22.2"	09^0, 07' 31.2"	123.17 ± 6.2199	40.486 ± 1.4018	71.415 ± 1.0265
C6	Fan B	Tomatoes	008^0 58' 19.5"	09^0, 07' 46.9"	51.78 ± 3.4209	28.74 ± 3.6376	52.806 ± 0.3422
C7	Foron A	Carrot	008^0 56' 40.7"	09^0, 39' 55.7"	132.79 ± 7.1529	32.785 ± 4.9815	47.331 ± 1.8704
C8	Foron B	Cabbage	008^0 55' 13.8"	09^0, 41' 46.8"	116.5 ± 7.6193	15.871 ± 6.6033	38.287 ± 1.8248
C9	Gassa A	Cabbage	008^0 54'	09^0, 35'	115.69 ±	21.664 ±	58.166 ±

			11.8"	02.1"	3.5764	9.2678	0.6843
C10	Gassa B	Cabbage	008^0 54' 07.0"	09^0, 34' 56.3"	198.26 ± 7.4638	75.69 ± 3.2437	50.411 ± 1.2546
C11	Gindin Akwati A	Maize	008^0 50' 12.3"	09^0, 28' 48.5"	107.6 ± 5.1314	40.547 ± 2.7804	85.242 ± 1.2548
C12	Gindin Akwati B	Cocoyam	008^0 50' 15.9"	09^0, 28' 36.8"	124.53 ± 3.4192	38.74 ± 3.6463	56.816 ± 1.3422
C13	Kassa A	Green beans	008^0 53' 44.9"	09^0, 35' 45.2"	122.4 ± 2.6439	12.048 ± 9.7312	89.282 ± 2.1665
C14	Kassa B	Cabbage	008^0 50' 36.2"	09^0, 35' 44.6"	144.3 ± 5.5979	23.865 ± 2.6645	47.787 ± 0.7527
C15	Kuru-Jenta A	Yam	008^0 50' 22.1"	09^0, 41' 24.7"	41.595 ± 0.6702	14.018 ± 6.6033	52.698 ± 1.7336
C16	Kuru-Jenta B	Cocoyam	008^0 52' 52.7"	09^0, 40' 49.8"	136.84 ± 4.1984	52.595 ± 3.823	81.661 ± 1.1063
C17	Rakwok A	Pepper	008^0 53' 07.4"	09^0, 28' 28.8"	90.314 ± 3.6249	46.376 ± 1.6219	62.692 ± 1.7336
C18	Rakwok B	Tomatoes	008^0 53' 09.9"	09^0, 28' 39.7"	105.78 ± 3.4638	75.69 ± 3.7061	56.219 ± 1.9236

C19	Tenti A	Tomatoes	008^0 55' 17.0"	09^0, 27' 57.4"	100.54 ± 4.2581	43.821 ± 2.6703	80.241 ± 1.3546
C20	Tenti B	Cabbage	008^0 55' 23.2"	09^0, 25' 08.1"	116.69 ± 3.5764	31.664 ± 9.2678	68.166 ± 0.6843
Mean					**114.756± 4.9919**	**42.4197± 4.6719**	**62.0086± 1.3697**