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Residual Effect of Rice Husk on Soil Properties in Makurdi, Southern Guinea Savanna Agroecology of Nigeria

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ABSTRACT

This study was carried out as a follow-up research from the 2015 cropping season at the Teaching and Research Farm of the University of Agriculture, Makurdi during the 2016 cropping season. The aim was to evaluate the residual effect of rice husk incorporation on the soil chemical properties. It involved the use of an experimental field previously applied with three rates of unburnt and four rates of burnt rice husk as soil amendment and the control, replicated three times in a Randomized Complete Block Design (RCBD) during the 2015 cropping season. Data was obtained on selected soil chemical and biological properties. They were analysed using standard laboratory procedures. Results indicated that the residual effect of rice husk improved soil chemical and biological properties in the succeeding growing season. It is recommended that burnt rice husk at 2.5 t/ha or 4 t/ha of unburnt rice husk could be applied to improve the soil chemical and organic matter content respectively for increased soil fertility in the study area.

Keywords: *Residual, Effect, Rice, Husk, Soil, Makurdi.*

INTRODUCTION

Inorganic fertilization is largely characterized by certain demerits which have made it necessary for the use of alternative sources of fertilization like organic fertilization which has proven in the long term to be a better supporter

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of plant growth and environmental sustainability (Onwu, Ayuba and Ali, 2009). The proliferation of agro-based industries in recent times has resulted to an increase in the production of agricultural wastes (Alhassan, Kundiri and Folorunso, 1998). Presently, improper disposal strategy of these wastes has led to environmental hazards such as water pollution, proliferation of plants and animal diseases and global warming (Karim, Qadir and Aziz, 2013). However, these agro-wastes contain essential nutrients needed for improvement of soil fertility, plant growth and yield (Oladipo, Olayinka and Aduayi, 2005). Many researchers have demonstrated the efficacy of some of these agro-wastes in improving soil physical and chemical properties as well as yield of tropical crops (Ayeni and Adeleye, 2011; Akanni and Ojeniyi 2007; Mbah and Nkpaji, 2010).

However, the utilization of these organic wastes by farmers is still poor despite their nutrient composition (Ayeni and Adeleye, 2011). The relative neglect of these wastes as soil amendments has partly been attributed to their bulkiness, low nutrient quality, high Carbon: Nitrogen and lignin: N ratios, high cellulose and pectin content and this takes them comparatively longer time to decompose and release nutrients to crops (Moyin-Jesu, 2008). These organic wastes, therefore, demand appropriate utilization in view of their plant nutrient potentials. Based on this, the best approach in the utilization of these carbonaceous wastes is either converting them into ashes (Ojeniyi, Oso and Arotolu, 2001) or complementing them with high nitrogen source materials to increase their mineralization process (Motavelli, Marler, Cruz and Connell, 2001). This will prevent temporary nitrogen drain by microbes (Ogbodo, 2009). Application of different organic fertilizers, e.g manures, plant residues and other waste materials is an effective management strategy to improve soil fertility, biological and chemical properties of soils and availability of micro nutrients (Goyal, Chander, Mundra and Kapoor, 1999, Rengel, Batten and Crowley, 1999, Schulin, Khoshgoftarmanesh, Afyuni, Nowack and Frossard, 2009). Since organic fertilizers slowly release their nutrients, their integrated use with chemical fertilizers is reported to be more beneficial (Olatunji, Ayuba and Ali, 2014).

Okonkwo, Mbagwu, Egwu and Mbah (2011) showed that the highest organic matter content can be obtained in the unburnt rice husk amended plots compared to the ash. They went further that this higher organic matter content level which could be observed in amended plots could be attributed to the fact that the organic material had major impact on mineralization rate and increased soil carbon directly. According to Nwite, Igwe and Obalum (2011) total Nitrogen may not be improved by the amendment of rice husk dust and rice husk ash. This also agrees with Okonkwo, Mbagwu, Egwu and Mbah (2011), who showed that unburnt rice husk had the lowest soil N which they attributed to either immobilization of available N after incorporation by micro-organisms or the utilization of the native soil N in order to initiate decomposition in the soil. The low level of improvement of N by rice husk agrees with Obatolu and Agboola, (1993) and Sobulo and Osiname (1987) reported that low N might be as a result of early mineralization.

Miller and Miller (2000) highlighted that organic material application and subsequent incorporation to crop land could affect soil properties, but that the effects generally may not be apparent over a short time. Ramamurthy and Shivashankar (1996) reported that organic fertilizers applied to preceding crop had a remarkable residual effect on the fertility of the succeeding season. In another study, Prasad (1994) observed residual effect was equivalent to 20% of NPK as chemical fertilizers on the succeeding rice-wheat and rice-maize cropping systems and concluded the slow release of these nutrients is responsible for the increase in crop yields in the subsequent years, thus determining the difficulty of quickly evaluating the true agronomic value of these organic materials as amendments. Odedina S., Odedina J., Ayeni, Arowofolu, Adeyeye and Ojeniyi, (2003) reported that organic wastes increased soil pH due to the abundance of alkaline earth materials. Their incorporation improves aeration in the root zone, improves soil water holding capacity and increases levels of exchangeable Potassium (K) and Magnesium (Mg) (FFTC, 2001).

Rice husks, and others like wood shavings, nut shells, manures and crop residues are regarded as agricultural waste, but recently such solid wastes have been transformed into ash/bio char for the purpose of carbon sequestration (Lehmann, Czimezik, Laird and Sohi, 2009). Rice husk takes a long time to decompose and release its nutrients even when incorporated into the soil (Ibrahim, 2015). Rice husks contain high content of silicon and potassium, nutrients which have great potential for amending the soil structurally. Burnt rice husk increases the soil pH, thereby increasing available phosphorus (Mbah and Nkpaji, 2010). Research has shown that incorporation of rice husks can significantly increase or improve soil properties by decreasing soil bulk density, enhancing soil pH, adding organic carbon, increasing available nutrients and removing heavy metals from the soil system, ultimately increasing crop yields (William, Morse, Ruckman and Guerrero, 1972). The previous use of rice husk as an organic fertilizer in the soil of the study area in the preceding year made it a compelling site for the residual effect of the rice husk to be studied. The objective of the work was to determine the residual effect of rice husks on the soil chemical and biological properties in Makurdi, Southern Guinea Savanna Agroecology of Nigeria.

MATERIALS AND METHOD

The experiment was carried out at the Teaching and Research Farm of the Federal University of Agriculture, Makurdi. The area is located on Latitude 7^o 41' N and Longitude 8^o 37' E, at 97 m above mean sea level and falls within the Southern Guinea Savanna Agroecological zone of Nigeria. The location has average rainfall of 1150 mm and average maximum daily temperatures vary between 30 and 35^oC (Agber, Wuese and Ali, 2017). The soil is shally (sandy loam), well drained, porous and brownish red below the surface, made of kaolinite clay and has a pH range of 5.0 - 6.5 (Abagyeh, 2015). The experiment was staged in an experimental field incorporated with rice husk the preceding farming season with eight treatments replicated three (3) times and laid out in a Randomized Complete Block Design (RCBD). Following the previous experimental layout where rice husk was incorporated, the experimental plots were marked out. Clearing and tillage was done manually using hoes. Each treatment had an area of 3 m x 3 m (9 m^2). Each plot was separated by a distance of 0.75 m and 1 m between each block, giving a total area of 357.5m^2.

Soil samples were collected at two depths (0-15 and 15-30 cm) from each of the treatments. They were packed in polythene bags, labelled appropriately and taken to the laboratory for analysis to determine selected soil chemical and biological properties. The samples were taken to the Analytical Soil Testing Laboratory of the Department of Soil Science, University of Agriculture, Makurdi for analysis. The soil samples were air dried at room temperature for 7 days and sieved through a 2 mm sieve, the samples were then analysed for the following soil properties, Particle size distribution (Bouyoucos, 1951), pH (Glass electrode by Black, 1965),

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Organic Carbon (Allison, 1965), Total Nitrogen (Black, 1965), Available P (Bray and Kurtz, 1945), Exchangeable Cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) by NH_4OAC as described by Thomas, 1982 and Cation Exchange Capacity (Dewis and Freitas, 1970).

RESULTS AND DISCUSSION

The meteorological data of the study area for 2016 revealed that temperature varied between 26.20 °C and 30.85 °C in the months of January and March respectively. Relative humidity was highest in the month of September (78.50%) and lowest in the month of January (21.00%). There was no rainfall in the dry season months of December, January and February. The highest rainfall was recorded in the month of September (269.80 mm), with total rainfall being 1,264.20 mm. The period of the experiment (June – October) enjoyed sufficient rainfall and conducive temperature as well as relative humidity for good crop development and yield.

There was decreased pH in the treatments previously treated with unburnt rice husk. The highest decrease was at 2 t/ha while there was increased pH at the burnt rice husk treatments, being highest at 2.5 t/ha. This is in agreement with Odedina *et al*., (2003) who reported that organic wastes increased soil pH due to the abundance of alkaline earth materials. This also agrees with Awodun, Otani and Ojeniyi (2007) that ash raises soil pH thus, it has a liming effect through the supply of basic elements especially calcium and potassium.

The organic matter increased at the end of the experiment with the highest increase at the 4 t/ha unburnt rice husk and lowest increase at the control. Okonkwo, Mbagwu, Egwu and Mbah (2011) had opined that the highest organic matter content was obtained in the unburnt rice husk amended plots compared to the ash. Nitrogen increased across the treatments, being highest at 4 t/ha unburnt rice husk while phosphorus had the highest increase at 2 t/ha unburnt rice husk. Okonkwo, Mbagwu, Egwu and Mbah (2011) however obtained low values of available phosphorus in the control and unburnt rice husk plots. They further showed that among the amended plots, unburnt rice husk had the lowest soil nitrogen which they attributed to either immobilization of available nitrogen after incorporation by microorganisms or the utilization of native nitrogen to initiate decomposition in the soil.

There was increase in potassium, sodium, magnesium and cation exchange capacity. This agrees with Ogbe, Jayeoba and Amana (2015) that decomposed rice husk, either burnt or unburnt significantly increased the concentration of the exchangeable bases. There was increased calcium in soils treated with both burnt and unburnt rice husk. Njoku and Mbah (2012) showed that the application of rice husk significantly increased the exchangeable bases of the soil relative to the control and in general, the increase was proportionate to the rate of application.

There was significant residual effect of rice husk on the number of leaves, plant height, number of branches, stem girth and number of pods at 14 WAP in all treatments, with 2.5 t/ha of burnt rice husk having the highest number of leaves, 6 t/ha unburnt rice husk having the tallest plants, 2 t/ha of unburnt rice husk having the highest number of branches and also the biggest stem girth. The highest number of pods was obtained at 2.5 t/ha of burnt rice husk. This was significantly higher than the yield at 3.5 t/ha of burnt rice husk, but was not significantly higher than the yield at 4.5 t/ha of burnt rice husk. This is in agreement with the assertion of Diacono and Montemurro (2010) that the slow release of nutrients of organic amendments is responsible for the increase in crop yield in subsequent years, thus determining the difficulty of quickly evaluating the true agronomic value of these organic materials as amendments.

Decreasing yields after addition of burnt rice husk at 2.5 t/ha is indicative that diminishing returns may have set in, therefore further addition of the ash may not lead to increased yield rather it could result into nutrient toxicity which leads to reduced crop performance. There was no significant difference among the unburnt rice husk rates from 2-6 t/ha, although 6 t/ha tended to perform better than the lower rates and more so, than the control.

CONCLUSION AND RECOMMENDATION

Arising from this work, it can be concluded that incorporation of rice husk as soil amendment improved the soil chemical properties and increase soil organic matter content in the study area in the succeeding growing season. It can be recommended that application of burnt rice husk at 2.5 t/ha and 4 t/ha unburnt rice husk could be used to improve the soil chemical properties and organic matter respectively and overall crop performance in the study area.

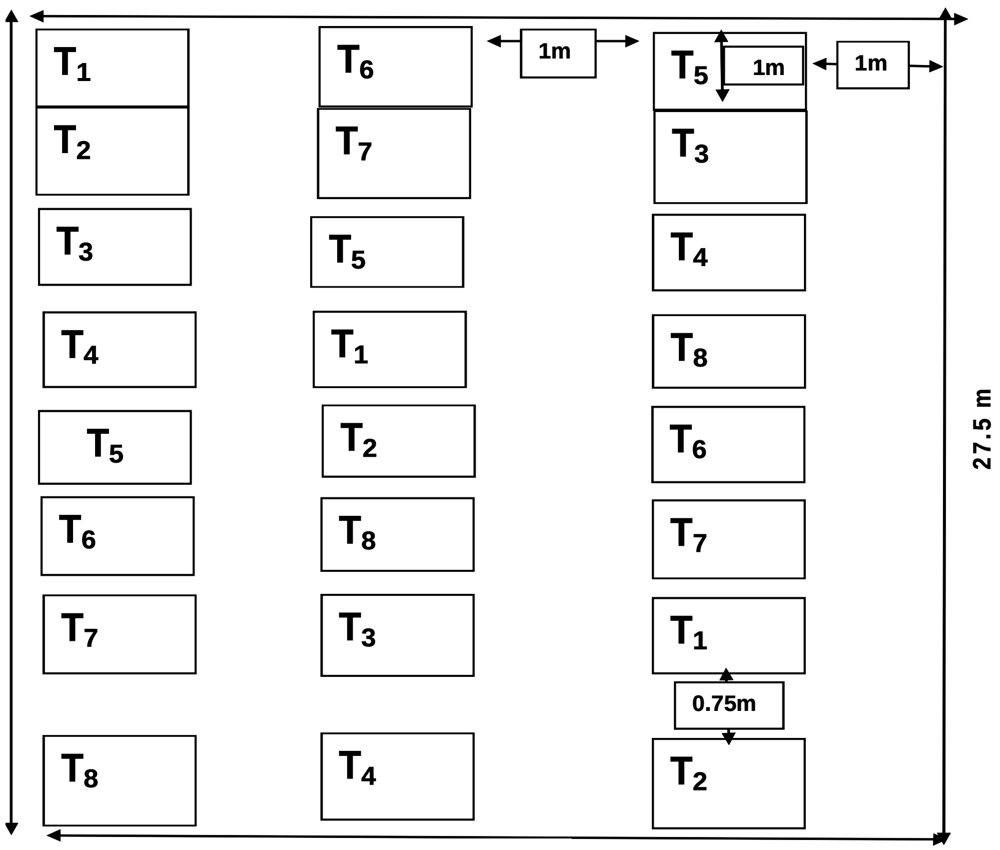

Table 1: Meteorological Data for Makurdi, 2016

Month	Rainfall (mm)	Temperature (°C)	Relative Humidity (%)
January	0.00	26.20	21.00
February	0.00	29.20	29.50
March	47.60	30.85	62.50
April	91.10	29.65	65.00
May	238.00	28.75	70.50
June	49.40	27.70	73.00
July	215.60	27.05	77.00
August	213.80	27.05	78.00
September	269.80	27.00	78.50
October	116.10	28.20	73.00
November	22.80	28.25	67.00
December	0.00	26.25	24.00
Total	1,264.20		

Source: Nigerian Meteorological Agency, Nigeria, Air Force base, Makurdi

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Table 2: Chemical Properties of the Soil of the Experimental Site before the Experiment

Sample	Depth (cm)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	pH (H_20)	OM (g/kg)	N (g/kg)	P (mg/kg)	K	Na	Ca	Mg	EA	EB	CEC	BS (%)
									→ (Cmol/kg) ←							
T1	0 – 15	798.20	131.00	70.80	6.77	13.00	0.34	0.31	0.21	0.18	2.04	2.41	0.80	4.84	5.64	85.81
T2	0 – 15	797.10	130.90	72.00	6.73	13.20	0.29	0.31	0.23	0.16	2.03	2.41	0.79	4.83	5.62	85.94
T3	0 – 15	798.00	130.60	71.40	6.81	14.60	0.40	0.37	0.28	0.21	2.11	2.51	0.87	5.11	5.98	85.45
T4	0 – 15	797.80	130.00	72.20	6.83	14.50	0.51	0.38	0.29	0.20	2.10	2.49	0.88	5.08	5.96	85.23
T5	0 – 15	798.40	131.10	70.50	6.85	18.00	0.46	0.43	0.30	0.27	2.23	2.61	0.93	5.41	6.34	85.33
T6	0 – 15	798.00	131.30	70.70	6.87	18.40	0.49	0.41	0.33	0.29	2.20	2.55	0.93	5.37	6.30	85.23
T7	0 – 15	797.70	131.60	70.70	6.91	20.10	0.56	0.47	0.41	0.39	2.27	2.71	0.98	5.78	6.76	85.50
T8	0 – 15	799.30	129.20	71.50	6.89	20.10	0.57	0.48	0.39	0.43	2.31	2.72	0.98	5.85	6.83	85.65

T1 – Control, T2 - 2 t/ha Unburnt rice husk, T3 - 4 t/ha Unburnt rice husk, T4 - 6 t/ha Unburnt rice husk, T5 - 1.5 t/ha Burnt rice husk, T6 - 2.5 t/ha Burnt rice husk, T7 - 3.5 t/ha burnt rice husk ; T8 - 4.5 t/ha Burnt rice husk. ***Source :*** Field data (2016).

Table 3: Status of Soil Chemical Properties before the Experiment

Sample	Depth (cm)	pH (H_20)	OM (g/kg)	N (g/kg)	P (mg/kg)	K (Cmol/kg)	Na (Cmol/kg)	Ca (Cmol/kg)	Mg (Cmol/kg)	CEC Cmol/kg)	BS (%)
T1	0 – 15	N	VL	VL	L	L	L	L	M	VL	VH
T2	0 – 15	N	VL	VL	L	L	L	L	M	VL	VH
T3	0 – 15	N	VL	VL	L	L	L	L	M	VL	VH
T4	0 – 15	N	VL	VL	L	L	L	L	M	VL	VH
T5	0 – 15	N	VL	VL	L	L	L	L	M	L	VH
T6	0 – 15	N	VL	VL	L	M	L	L	M	L	VH
T7	0 – 15	N	L	VL	L	M	M	L	M	L	VH
T8	0 – 15	N	L	VL	L	M	M	L	M	L	VH

N - Neutral, L- Low , VL - Very Low, M - Medium; VH - Very High. *Source:* Field data (2016)

Table 4: Chemical Properties of the Soil of the Experimental Site after the Experiment

Sample	Depth (cm)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	pH ($H_2$0)	OM (g/kg)	N (g/kg)	P (mg/kg)	K	Na	Ca	Mg	EA	EB	CEC	BS (%)
									→				(Cmol/kg)		←	
T1	0 – 15	798.20	130.90	71.10	6.79	13.90	0.36	0.29	0.18	0.16	2.39	2.03	0.79	4.76	5.55	85.77
	15 – 30	801.20	128.80	70.00	6.82	13.70	0.34	0.26	0.16	0.20	2.41	2.02	0.28	4.79	5.61	85.38
T2	0 – 15	796.70	130.60	72.70	6.77	13.80	0.31	0.28	0.18	0.14	2.38	2.02	0.77	4.72	5.49	85.98
	15 – 30	798.10	130.30	71.60	6.81	13.10	0.28	0.25	0.16	0.18	2.44	2.01	0.80	4.79	5.59	85.69
T3	0 – 15	797.80	130.70	71.50	6.84	14.90	0.44	0.39	0.25	0.19	2.46	2.09	0.83	4.99	5.82	85.74
	15 – 30	797.90	130.30	71.80	6.86	15.00	0.38	0.36	0.22	0.21	2.44	2.05	0.82	4.92	5.72	86.01
T4	0 – 15	797.60	128.60	73.80	6.81	14.90	0.54	0.39	0.27	0.17	2.44	2.06	0.85	4.94	5.79	85.32
	15 – 30	798.10	130.30	71.60	6.85	15.20	0.42	0.37	0.21	0.16	2.42	2.05	0.80	4.84	5.64	85.82
T5	0 – 15	797.70	130.10	72.20	6.83	18.80	0.49	0.44	0.28	0.24	2.54	2.17	0.93	5.23	6.16	84.90
	15 – 30	797.90	130.80	71.30	6.87	17.50	0.41	0.36	0.26	0.22	2.45	2.11	0.86	5.04	5.90	85.42
T6	0 – 15	798.10	130.20	71.70	6.84	18.90	0.51	0.43	0.29	0.26	2.53	2.17	0.90	5.25	6.15	85.37
	15 – 30	798.50	130.20	71.30	6.87	17.30	0.46	0.39	0.27	0.24	2.42	2.09	0.87	5.02	5.89	85.23
T7	0 – 15	797.50	130.80	71.70	6.89	21.40	0.59	0.49	0.37	0.36	2.67	2.24	0.97	5.64	6.61	85.33
	15 – 30	800.40	131.10	68.50	6.78	19.80	0.45	0.42	0.29	0.31	2.41	2.21	0.91	5.22	6.13	85.16
T8	0 – 15	79.89	12.97	71.40	6.87	21.20	0.58	0.49	0.36	0.35	2.66	2.24	0.97	5.61	6.53	85.26
	15 – 30	79.92	13.01	70.70	6.89	20.20	0.47	0.46	0.28	0.30	2.50	2.20	0.90	5.28	6.18	85.44

T1 - Control, T2 - 2 t/ha Unburnt rice husk, T3 - 4 t/ha Unburnt rice husk, T4 - 6 t/ha Unburnt rice husk, T5 - 1.5 t/ha Burnt rice husk, T6 - 2.5 t/ha Burnt rice husk, T7 - 3.5 t/ha burnt rice husk; T8 - 4.5 t/ha Burnt rice husk. ***Source:*** Field data (2016).

Table 5: Status of Soil Chemical Properties after the Experiment

Sample	Depth (cm)	pH (H_20)	OM (g/kg)	N (g/kg)	P (mg/kg)	K (Cmol/kg)	Na Cmol/kg	Ca Cmol/kg	Mg Cmol/kg	CEC Cmol/kg	BS (%)
T1	0 – 15	N	VL	VL	L	VL	L	L	M	VL	VH
	15 – 30	N	VL	VL	L	VL	L	L	M	VL	VH
T2	0 – 15	N	VL	VL	L	VL	L	L	M	VL	VH
	15 – 30	N	VL	VL	L	VL	L	L	M	VL	VH
T3	0 – 15	N	VL	VL	L	L	L	L	M	VL	VH
	15 – 30	N	VL	VL	L	L	L	L	M	VL	VH
T4	0 – 15	N	VL	VL	L	L	L	L	M	VL	VH
	15 – 30	N	VL	VL	L	L	L	L	M	VL	VH
T5	0 – 15	N	VL	VL	L	L	L	L	M	L	VH
	15 – 30	N	VL	VL	L	L	L	L	M	VL	VH
T6	0 – 15	N	VL	VL	L	L	L	L	M	L	VH
	15 – 30	N	VL	VL	L	L	L	L	M	VL	VH
T7	0 – 15	N	L	VL	L	M	M	L	M	L	VH
	15 – 30	N	VL	VL	L	L	M	L	M	L	VH
T8	0 – 15	N	L	VL	L	M	M	L	M	L	VH
	15 – 30	N	L	VL	L	L	M	L	M	L	VH

N – Neutral, L – Low, VL - Very Low, M – Medium; VH-Very High. Source: Field data (2016).

Table 6: Percentage Change in the Soil Chemical Properties at the end of the Experiment

Sample	Depth (cm)	pH (H_20)	OM (g/kg)	N (g/kg)	P (mg/kg)	K	Na	Ca	Mg	CEC	BS (%)
						(Cmol/kg) →					
T1	**0 – 15**	**0.29**	**6.47**	**5.56**	**-6.90**	**-16.67**	**-12.50**	**14.64**	**18.72**	**-1.62**	**-0.05**
T2	**0 – 15**	**0.59**	**4.35**	**6.45**	**-10.71**	**-27.78**	**-14.29**	**14.71**	**19.31**	**2.37**	**0.05**
T3	**0 – 15**	**0.44**	**2.01**	**9.09**	**5.13**	**-12.00**	**-10.53**	**14.23**	**20.10**	**2.75**	**0.34**
T4	**0 – 15**	**-0.29**	**2.68**	**5.56**	**2.56**	**-7.41**	**-17.65**	**13.93**	**20.87**	**2.94**	**0.11**
T5	**0 – 15**	**-0.29**	**4.26**	**6.12**	**2.27**	**-7.14**	**-12.50**	**12.20**	**20.28**	**2.92**	**-0.51**
T6	**0 – 15**	**-0.44**	**2.65**	**3.92**	**4.65**	**-13.79**	**-11.54**	**13.04**	**13.84**	**2.44**	**0.16**
T7	**0 – 15**	**-0.29**	**6.07**	**5.08**	**4.08**	**-10.81**	**-8.33**	**14.98**	**20.98**	**2.27**	**0.20**
T8	**0 – 15**	**-0.29**	**5.19**	**1.72**	**2.04**	**-8.33**	**-22.86**	**13.16**	**21.43**	**4.59**	**0.46**

Source: Field data (2016)

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