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Rattle Tree (*Albizia lebbeck* Benth.) Effects on Potato (*Solanum tuberosum* L.) Productivity on the Jos Plateau, Nigeria

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Summary: Field experiment was conducted in the biotite-granite area (Alfisol) of the Jos Plateau, Nigeria, consisting of five cropping seasons to determine the effects of the tree rows (under alley cropping) and green manure of *Albizia lebbeck* Benth. (rattle tree) on the yield / productivity of *Solanum tuberosum* L. (Irish potato). The experiment was a randomized complete block design comprising five treatments and three replicates. An early maturing potato variety (Bertita) was employed, its pre-sprouted tubers were planted in the alleys (spaces between the tree rows) of *A. lebbeck* two weeks after green manure was applied (5 and 10 t ha^{-1}), pre and post experimental soil sample analyses and cultivation operations were carried out. Results indicated that the rattle tree had profound effect on the potato growth parameters (plant height, leaf count, collar girth (at $P \leq 0.01$)) and yield indices (tuber count ($P \leq 0.05$) and tuber weight ($P \leq 0.01$)) due to nutrients from the green manure and nitrogen fixation activities of the rattle tree. *A. lebbeck* green manure application at 10 t ha^{-1} in the alleys of *A. lebbeck* hedgerows emerged as the most effective treatment in terms of growth performance and optimal yield. Collar girth and leaf count of the potato accounted for 80.4 – 91.3% of the variation in yield (R^2 = 0.804 – 0.913) with collar girth having the highest value (R^2 = 0.910) in rainy season (rain fed) cropping, while leaf count had the highest value (R^2=0.913) during the dry season (irrigated) cropping.
Keywords: tubers, Albizia, green manures, potatoes, nitrogen fixation

Introduction

The nitrogen fixing trees (NFT) have an edge over the non-nitrogen fixing ones in the sphere of nitrogen fixation due to the presence of *Rhizobium* bacteria in their root nodules. Some NFT also have the ability to nodulate with the ubiquitous *Bradyrhizobium* bacterial strain in the soil, thereby increasing the nitrogen status of the soil (Sanginga & Mulongoy 1995). Certain tree species and selected agronomic crops are parts of the components of agroforestry system. The trees enhance the productivity of the crops through some of their activities such as nitrogen fixation, erosion control and addition of organic matter.

Right from time immemorial, trees have often been left in farmlands in scattered manner which are later utilized by farmers for various purposes (such as fuel wood, timber, fodder/forage, gum, tannins, fencing poles, stakes, medicinal uses, etc.) in addition to their roles in soil conservation (Kareem 2008). Further steps have been taken in utilizing some multipurpose tree species (MPTS) to improve soil nutrient status and crop yield. One of such steps is the use of green manure obtained from the trimming or pruning of hedgerows or trees in or around farms. When appropriate quantity of foliage is applied to soils (as green manure) it could bring about optimum production per unit area and even substitute for chemical fertilizer requirements (Kwapata et al. 1992).

The rattle tree (*Albizia lebbeck* Benth.) belongs to the family Leguminosae and subfamily Mimosaceae. It is a nitrogen fixing tree and its green manure when incorporated into the soil brings about reasonable soil improvement and enhances crop yield (Hunter et al. 1995, Kareem 2008). Irish potato (*Solanum tuberosum* L.)

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was said to have originated from the Alti plano around the Lake Titicaca at an altitude of about 3000 m in the Bolivian Andes (Burton 1966, Kay 1987). Ifenkwe (1981) said that South America was the origin and it was introduced to Nigeria in the late 19th century and early 20th century by Europeans, notably tin miners in Jos Plateau and the Germans in Cameroon, while Mills (2001) reported that it originated in the Andian regions of Peru and Bolivia. It did not originate from Ireland (Britain) but it is so called (Irish potato) because its planting stock was procured from Ireland by Scotch Irish immigrants and this crop is also very popular in Ireland, hence the name Irish Potato (Yayock et al. 1988). It belongs to the Solanaceae family and is one of the major root crops in Nigeria which serves as food crop and source of reasonable revenue to farmers in Jos, Biu, Manbilla Plateaux and the Obudu Hills (Ifenkwe & Udurukwe 1990). Nutritionally, Beukema & Van Der Zaag (1979) reported from an experiment that fried potato gave higher calorie (energy value) than potato boiled or roasted with skin, but the potato tuber boiled or roasted with skin produced the highest values in minerals, protein and vitamins to the body. Annual production has been estimated at 100,000 tons (Ifenkwe & Suchomel 1983, Ifenkwe 1987) with the aid of chemical fertilizer.

The principal objective of this study was to investigate the effects of the hedge/tree rows and green manure of the rattle tree on the productivity of this crop without the use of inorganic fertilizer. Since most tropical soils are highly weathered, leached and organic matter content is very low (Adepetu et al. 1979), there was need to embrace 'organic farming' due to the destructive effects of inorganic fertilizers on the impoverished soils of the Jos Plateau sequel to continuous cultivation.

Materials and Methods

This experiment was conducted in the Federal College of Forestry, Jos Plateau Nigeria (between latitudes 8° 30' and 10^0 10'N and longitudes 8^0 20' and 9^0 30'E, altitude of about 1250 m, mean annual rainfall of 1260 mm and mean annual temperature of about 22^{0}C (Macleod & Turner 1971, Hill 1976, Udo 1978). Prior to clearing of the experimental site, soil (Alfisol) samples were randomly collected from the site in order to assess the initial nutrient status of the soil and also use the result of the laboratory analysis as the basis for block design.

Three locations were randomly selected as major locations followed by random selection of 4 sub-locations from each major location. Subsequently, soil samples were collected from each sub-location at three soil depths: 0-10, 10-25, 25-40 cm. Composite samples from each major location were used for analysis. Thus, a total of 9 samples (3 from each of the major locations) were analysed and taken as initial nutrient status of the experimental site.

The design of the experiment was a randomized complete block design with five treatments and three replicates (which represented the blocks). Clearing of the site was done manually and the area (24 m x 12 m) harrowed, 15 mini plots denoting the five treatments and three replicates were constructed (5 mini plots per block). Each mini plot was 3 m x 2 m (6 m^2) in size and an embankment (levee) was made between two adjacent mini-plots to prevent run-off from one plot to another within blocks which could have partially involved transfer of nutrients (in addition to 1.5 m distance between blocks). The experiment was conducted on Irish potato in 5 cropping seasons (rain fed and irrigated) over 3 years. Seedlings of the rattle tree which had been raised and were six months old were planted when rain stabilized in the month of May based on the treatments.

The five treatments (T) were as follows:

T_O = Plot without green manure and tree rows of *A. lebbeck* (as control)

T_1 = plot without green manure of *A. lebbeck* but with its tree/hedgerows.

T_2 = Plot with green manure of *A. lebbeck* (incorporated into the soil) at 5 t/ha but without its tree rows

T_3 = Plot with green manure of *A. lebbeck* (applied on soil surface) at 5 t/ha and its tree rows.

T_4 = plot with green manure of *A. lebbeck* (incorporated into the soil) at 10 t/ha and its tree rows

Cultivation operations such as weeding, pest (rodent) control, fire-tracing during dry season cropping, erosion control and shade reduction of the *A. lebbeck* tree-rows (at the 2nd - 5th planting seasons) were carried out. During shade reduction, pruning was avoided in order to prevent root nodule senescence and decay within three weeks of pruning (Dommergues & Ahmad 1995) which could have inhibited nitrogen fixation activities of the *A. lebbeck* tree-rows. Thus, the leaves were manually detached from the basal and upper parts of the trees. The frequency of irrigation was every two days. It is pertinent to stress here that soil moisture was maintained at field capacity during tuber initiation / tuberization and bulking, but reduced to 50% at maturation. Application of water continued until 7 days to harvest. About 500-600 mm of water was applied (Okonkwo et al. 1995, Mills 2001, King et al. 2003, Pawar & Dingre 2014).

Parameters investigated during the five planting seasons include some growth indices (plant height, leaf count, stem count and collar girth) and yield parameters (tuber count and tuber weight). Pre and post experimental soil nutrient analyses in respect of pH, organic matter, total nitrogen, available phosphorus, Ca, Mg, K, Na, exchangeable acidity and effective cation exchange capacity were performed at the Soil Science Laboratory of the Ahmadu Bello University Zaria, Kaduna State, Nigeria. Determination of the particle size distribution of the soil samples was done by employing the hydrometer method (Day 1965) and separated into sand, silt and clay and expressed in percentages, while the pH (1:2:5) in water and KCl was determined electronically by using a functional pH meter. Flame photometer was employed in the determination of the exchangeable cations (bases) such as Na and K while estimation of the Ca, Mg was done by means of atomic absorption spectrometer (AAS). Effective cation exchange capacity was determined by summation method following the extraction of exchangeable acidity with the aid of IN KCL. Coleman (in Kamprath 1984) suggested that the determination of cation exchange capacity through the summation of exchangeable bases plus KCL exchangeable acidity serves as a more realistic method of evaluating the actual amount of bases available to plants. The percentage organic carbon content was determined by potassium dichromate method of Walkey & Black (1974), available phosphorus by Bray & Kurtz (1945) method and total nitrogen by Kjeldahl method (Jackson 1962).

Results and Discussion

Based on the data obtained from the growth parameters, significant effect of the treatments on plant height, leaf count and collar girth ($P \geq 0.01$) throughout the cropping seasons was observed probably due to the different rates of green manure application and presence or absence of *A. lebbeck* tree-rows. T_4 had the highest mean values from all the growth parameters (Table 1). However, no block effect was observed in all the cropping seasons. Conversely, stem count was not significantly affected by the different treatments applied. With regard to season and treatment x season, significant effects were observed in all the growth parameters (either at $P = 0.01$ or $P = 0.05$) except in stem count.

The statistically significant differences observed among the treatments with regard to some growth parameters (plant height, leaf count and collar girth) could be attributed to the different rates and modes of *Albizia lebbeck* green manure application and presence or absence of its (*A. lebbeck)* tree rows. The highest mean values observed in T_4 (at 63 DAP) was probably due to its higher nutrient status as a result of its being the treatment with the highest level of green manure application (10 t ha^{-1}) coupled with the nitrogen fixation activities of the *A. lebbeck* tree-rows. This is in agreement with Mureithi et al. (2004) regarding the effect of a nitrogen fixing legume called purple vetch (*Vicia benghalensis).* In the same trend, T_2 without *A. lebbeck* tree row but with its green manure at 5 t ha^{-1} ranked second owing to the fact that the potato crops solely utilized the nutrient available as opposed to T_3 which had tree rows with green manure application (at 5 t ha^{-1} like T_2) as mulch. The tree rows (*A. lebbeck)* in the plot must have shared the available nutrients with the potato crops (in T_3). Only the tree rows in T_1 could probably have been the only source of additional nutrients (owing to nitrogen fixation activities), whereas T_0 had neither tree-rows nor green manure application. This was probably the reason why T_0 had the least values (of the growth indices). From another perspective, the treatments brought about the different values of the growth parameters which in turn resulted to variation in yield at different levels. Collar girth and leaf count of the potato accounted for 80.4 – 91.3% of the variation in yield ($R^2 = 0.804 – 0.913$) with collar girth having the highest value ($R^2 = 0.910$) in rainy season (rain fed) cropping while leaf count had the highest value ($R^2=0.913$) during the dry season (irrigated) cropping (Tables 2 to 9).

Table 1. Growth and yield parameters (mean values) of Irish potato in the cropping seasons

Treatments (5)	Growth Parameters						Yield Parameters	
	%S.E. (7 DAP)	%S.E (14 DAP)	Plant Ht (cm)	Leaf Count	Stem Count	Collar Girth(cm)	Tuber Count	Tuber Yield (t/ha)
1st Season								
T_0	70.0a	97.0a	44.7d	24.7d	3.0a	2.2e	112.3c	5.03d
T_1	52.06b	98.0a	51.3c	27.0d	2.7ab	2.8d	109.0c	5.08d
T_2	41.0c	97.0a	53.7c	41.3b	2.3ab	3.07c	139.0b	8.36b
T_3	62.0ab	97.7a	55.7b	35.7c	2.3ab	3.4b	113.0c	7.98c
T_4	57.3b	99.0a	66.3a	56.7a	2.0b	4.5a	160.7a	9.36a
2nd Season								
T_0	29.7b	92.7ab	48.0e	30.0c	2.3b	2.3e	79.7d	5.19e
T_1	24.3c	90.0ab	55.7d	35.0c	2.7a	3.0d	111.0c	5.43d
T_2	24.0c	87.0b	58.7c	53.0b	3.0a	3.4c	153.7a	9.72b
T_3	33.7a	87.7b	62.3b	52.0b	2.3b	3.5b	127.7b	8.90c
T_4	24.7c	95.0a	68.3a	67.3a	3.0a	4.7a	160.7a	10.41a
3rd Season								
T_0	58.3b	94.7b	62.0c	36.7d	3.0a	2.4e	92.3c	5.30e
T_1	54.7b	98.3a	65.0bc	52.3c	3.0a	3.3d	94.7c	5.40d
T_2	43.7c	98.0a	67.7b	61.7b	3.0a	3.6c	151.7a	9.13b
T_3	71.7a	97.7ab	63.7c	64.0b	2.7a	3.5b	118.0b	8.61c
T_4	56.7b	97.0ab	75.3a	70.3a	2.7a	4.9a	93.7c	9.80a
4th Season								
T_0	36.3b	93.0ab	64.7d	44.0e	3.0a	2.5e	95.7bc	5.22d
T_1	31.0c	92.0b	70.3c	60.0d	3.0a	3.5d	93.7c	5.74c
T_2	29.0c	95.0ab	76.3b	66.0c	2.0b	4.3b	142.7a	9.61a
T_3	33.0bc	84.0c	74.3b	72.3b	2.3b	4.1c	103.3b	8.90b
T_4	41.0a	97.0a	80.7a	77.7a	2.3b	5.3a	87.0d	9.73a
5th Season								
T_0	61.0a	93.0a	63.7d	46.0c	2.7a	3.1e	97.0c	5.28e
T_1	55.3a	91.7a	70.7c	72.3b	2.7a	3.5d	91.0c	5.85d
T_2	59.0a	92.3a	77.3b	71.0b	2.3a	4.4b	160.7a	9.63b
T_3	59.3a	94.0a	71.3c	70.3b	2.7a	4.2c	142.7b	9.02c
T_4	63.0a	94.0a	82.3a	78.7a	2.3b	5.3a	161.7a	11.96a

S.E. = Seedlings' Emergence. Mean values with the same letters are not significantly different at 5% level by Duncan's Multiple Range Test (DMRT). See Materials and Methods for what To -T_4 denote

Table 2. ANOVA Showing the Effect of Block, Treatment Season and Treatment x Season on **Plant Height** at 63 DAP

Source of Variation (S.V.)	Degree of Freedom (D.F)	Sum of Squares (S.S.)	Mean Square (M.S)	F Cal. Value	Probability Level
Block	2	3.92	1.96	0.47	0.6287 NS
Treatment	4	2572.53	643.13	153.78	< 0.0001***
Season	4	4364.27	1091.07	260.88	< 0.0001***
Treatment x Season	16	238.53	14.91	3.56	< 0.0500*
Error	48	200.75	4.18	-	-
Total	74	7380.00	-	-	-

*** = Highly Significant at 1%, * = Significant at 5%, NS = Not Significant.

Table 3. ANOVA Showing the Effect of Block, Treatment, Season and Treatment x Season on **Leaf Count** of Irish Potato at 63 DAP.

Source of Variation (S.V.)	Degree of Freedom (D.F)	Sum of Squares (S.S.)	Mean Square (M.S)	F Cal. Value	Probability Level
Block (Replicate)	2	4.67	2.33	0.66	0.5194 NS
Treatment	4	7600.00	1900.00	540.71	< 0.0001***
Season	4	8438.80	2109.70	600.39	< 0.0001***
Treatment x Season	16	1038.53	64.91	18.47	< 0.0100**
Error	48	168.67	3.51	-	-
Total	74	17250.67	-	-	-

*** = Highly Significant at 1%, ** = Significant at 1%, NS = Not Significant

Table 4. ANOVA Showing the Effect of Block, Treatment, Season and Treatment x Season on **Stem Count** Potato at 63 DAP

Source of Variation (S.V.)	Degree of Freedom (D.F)	Sum of Squares (S.S.)	Mean Square (M.S)	F Cal. Value	Probability Level
Block (Replicate)	2	0.19	0.093	0.46	0.6362 NS
Treatment	4	1.92	0.480	2.35	0.0676 NS
Season	4	1.52	0.380	1.86	0.1331 NS
Treatment x Season	16	4.35	0.272	1.33	0.2194 NS
Error	48	9.81	0.204	-	-
Total	74	17.79	-	-	-

NS = Not Significant

Table 5. ANOVA Showing the Effect of Block Treatment, Season and Treatment x Season on **Collar Girth** of Irish Potato at 63 DAP

Source of Variation (S.V.)	Degree of Freedom (D.F)	Sum of Squares (S.S.)	Mean Square (M.S)	F cal. Value	Probability Level
Block (Replicate)	2	0.006	0.003	1.50	0.2340 NS
Treatment	4	51.282	12.821	6494.52	< 0.0001***
Season	4	7.064	1.766	894.62	< 0.0001***
Treatment x Season	16	1.77	0.111	56.12	< 0.0001***
Error	48	0.095	0.002	-	-
Total	74	60.219	-	-	-

*** = Highly Significant at 1%, NS = Not Significant

Table 6. ANOVA Showing the Effect of Block, Treatment, Season and Treatment x Season on **Tuber Count** of Irish Potato

Source of Variation (S.V.)	Degree of Freedom (D.F)	Sum of Squares (S.S.)	Mean Square (M.S)	F Cal. Value	Probability Level
Block (Replicate)	2	978.11	489.053	1.67	0.5199 NS
Treatment	4	18898.59	4924.65	16.09	< 0.0001***
Season	4	7460.72	1990.18	6.78	< 0.01**
Treatment x Season	16	19420.21	1213.76	4.13	< 0.05*
Error	48	14098.56	293.72	-	-
Total	74	61356.19	-	-	-

*** = Highly Significant at 1%,** = Significant at 1%, NS = Not Significant

Table 7. ANOVA Showing the Effect of Block Treatment, Season and Treatment x Season on **Tuber Yield** of Irish Potato at 63 DAP.

Source of Variation (S.V.)	Degree of Freedom (D.F)	Sum of Squares (S.S.)	Mean Square (M.S)	F cal. Value	Probability Level
Block (Replicate)	2	0.067	0.033	2.28	0.1137 NS
Treatment	4	315.716	78.929	5390.46	< 0.0001***
Season	4	11.235	2.809	191.82	< 0.0001***
Treatment x Season	16	9.36	0.585	39.96	< 0.0001***
Error	48	0.703	0.015	-	-
Total	74	337..081	-	-	-

*** = Significant at 1%.

Table 8. Multiple regression and correlation analyses: growth parameters versus yield of Irish potato (rain fed)

Variables	'a'	Std Error	Multiple R	R Square	F-Value	P Value
X_1	0.310	0.096	0.881	0.777	10.450	0.048*
X_2	0.173	0.047	0.905	0.820	13.653	0.034*
X_3	-5.982	1.761	-0.891	0.794	11.540	0.0426*
X_4	2.308	0.419	0.954	0.910	30.424	0.012**

* Significant at 5%, ** Significant at 1%

Table 9. Multiple regression and correlation analyses: growth parameters versus yield of Irish potato (irrigated)

Variables	'a'	Std Error	Multiple R	R Square	F-value	P. value
X_1	0.304	0.080	0.911	0.830	14.645	0.031*
X_2	0.150	0.027	0.956	0.913	31.631	0.011**
X_3	-6.314	5.214	0.573	0.328	1.467	0.313·
X_4	2.313	0.659	0.897	0.804	12.335	0.039*

* Significant at 5%, ** Significant at 1%, ·Not significant

Variable Description for Tables 8 and 9: X_1 denotes Plant Height , X_2 denotes Leaf Count (number of leaves), X_3 denotes Stem Count, X_4 denotes Collar girth, a = Incercept [the part the of the dependent variable (yield) that does not change or vary with change in the independent variables (plant height, leaf count, collar girth and stem count)], R^2 = Coefficient of determination = proportion of variation in the dependent variable which is explained by the independent variable.

Hunter et al. (1995) and Dhakal et al. (2011) reported that application of plant biomass (foliage) and growing of trees in association with crops do bring about soil fertility improvement through soil moisture conservation and increase in nitrogen and organic matter status.

Tuber count was significantly influenced by the treatments during the study. Significant effect of season and treatment x season was also observed whereas no block effect was recorded. T_4 had the highest % quantity of tubers with large sizes (>50 mm diameter) followed by T_2, T_3, T_1 and T_0. Pertaining to tuber yield, treatments and seasons had significant effects on it (P = 0.01). T_4 had the maximum tuber yield (tuber weight) in all the five cropping seasons (CS), it recorded 9.36, 10.41, 9.80, 9.73 and 11.96 t ha^{-1} in CS_1, CS_2, CS_3, CS_4 and CS_5 respectively. It is pertinent to highlight here that the mean value of the CS_1, CS_3 and CS_5 (rain fed) was 7.11 t ha^{-1}, while that of CS_2 and CS_4 (irrigated) was 7.88 t ha^{-1}. It was also observed that this Bertita variety attained maturity within 60 days unlike other varieties that take longer periods of 3-4 months (90-120 days).

The significant influence of treatments on tuber count and tuber yield was probably due to the effect of the different levels of green manure application and the *Albizia lebbeck* tree rows. This is in accordance with the observation by Iwuafor & Kumar (1992) on the effect of *Leucaena leucocephala* foliage under alley cropping with maize. Also, Budelman (2002) made similar observation on the effect of *Gliricidia* leaf mulch on early development and yield of water yam (*Dioscorea alata*). The tuber yield ranged in $T_4 > T_2 > T_3 > T_1 > T_0$ owing to the influence of the different rates of green manure application and N_2 fixation activities of *A. lebbeck* trees.

Also, significant effect of treatments and blocks on some soil properties such as available phosphorus and potassium ($P \leq 0.05$) were observed. There was a general decrease in the organic matter, total nitrogen, calcium, sodium, exchangeable acidity and effective cation exchange capacity after planting (at the end of the experiment) probably due to leaching, absorption by the crops and crop removal (Table 10).

Table 10. Some chemical properties of the pre-experimental soil samples as influenced by the treatments after planting at three soil depths

Treatments	pH		OM	TN	Avail. P	Ca	Mg	K	Na	E.A	ECEC
	H_20	KCl	(%)	(%)	(ppm)		cmol (+) Kg^{-1}				
Before Planting (Tp)											
0 – 10 cm Depth	4.5b	4.2ab	1.94a	0.10ab	23.45a	4.07a	0.78b	0.22a	0.18ab	0.87a	6.12a
After Planting (0 – 10 cm)											
T_0	5.2a	4.5a	1.22b	0.06b	15.52b	2.06c	0.61c	0.17ab	0.15b	0.73a	3.72b
T_1	4.5b	4.3ab	1.29b	0.06b	16.40b	2.07c	0.63c	0.11ab	0.19ab	0.54a	3.54c
T_2	5.2a	4.5a	1.38b	0.06b	24.62a	3.00ab	0.72b	0.14ab	0.23a	0.80a	4.89ab
T_3	5.1a	4.0b	1.45b	0.08b	6.45c	2.67b	0.69c	0.20a	0.19ab	0.73a	4.48ab
T_4	4.7ab	4.1b	1.69a	0.33a	18.90b	3.07ab	0.93a	0.17ab	0.20a	0.60a	4.97ab
Before Planting (10 – 25 cm)	4.3b	3.9a	1.15b	0.07a	3.79c	3.93a	0.80b	0.15a	0.20a	1.20a	6.28a
After Planting (10 – 25 cm)											
T_0	4.9b	4.5a	1.03c	0.05a	10.92b	2.40b	0.46c	0.14a	0.17ab	1.13a	4.30b
T_1	4.8b	4.2ab	1.24b	0.07a	18.22a	3.07ab	1.16a	0.11a	0.20a	0.73b	5.27ab
T_2	5.1ab	4.4a	1.26b	0.08a	13.79ab	1.81c	0.34c	0.17a	0.26a	1.07a	3.65b
T_3	5.4a	4.4a	1.57a	0.08a	7.29c	2.87b	0.81b	0.19a	0.20a	1.47a	5.54ab
T_4	5.1ab	4.5a	1.38a	0.08a	10.38b	3.27a	0.99b	0.17a	0.18a	1.07a	5.68ab
Before Planting (25 – 40 cm)	4.3b	3.7a	0.79c	0.07a	3.04b	3.60a	0.52c	0.18b	0.27a	1.87a	6.44a
After Planting (25 – 40 cm)											
T_0	5.1a	4.6a	0.95c	0.06a	4.46b	2.87b	1.19a	0.16b	0.18ab	1.40ab	5.80ab
T_1	5.3a	4.4a	1.05b	0.07a	3.90b	2.73b	0.66b	0.14b	0.21ab	1.13b	4.87b
T_2	4.8b	4.4a	1.14a	0.31b	4.43b	2.20c	0.76b	0.47a	0.16ab	1.33b	4.92b
T_3	5.4a	4.4a	1.15a	0.07a	5.02a	2.53b	1.07a	0.16b	0.16ab	1.53a	5.45b
T_4	4.9b	4.5a	1.03b	0.27b	6.88a	1.93c	0.29c	0.13b	0.15ab	1.13b	3.63ab

OM = Organic Matter, TN = Total Nitrogen, E.A = Exchangeable Acidity, ECEC = Effective Cation Exchange Capacity. Each value represents mean value from three replicates from a treatment. Mean values with the same letters are not significantly different at 5% Probability level by DMRT. See Section 2.0 for what T0 –T4 denote.

Furthermore, significant difference observed in block effect in pH could be attributed to addition of organic matter in form of green manure from *Albizia lebbeck* since the pH of H_20 was initially low (4.5) before planting which made the soil very strongly acidic (Trough 1948, Olowolafe 2003) but increased to a range of 5.1 – 5.4 in T_2 – T_4 which indicates the influence of green manure addition. Kunishi (1982) and Olowolafe (2003) earlier reported that organic matter raises the soil pH, helps in ameliorating phyto-toxicity in acid soils, decreases soluble manganese and exchangeable aluminium (Al) and increases calcium and available phosphorus. Generally low organic matter and total nitrogen could be due to crop removal, leaching and volatilization (of N_2) in the site (Landon 1991, Olowolafe 2003). The organic matter in T_0 – T_4 after planting was lower than the value before planting.

The available phosphorus value was relatively high at the site before the experiment due to the fact that the soils were derived from biotite granites which contain relatively high available phosphorus and high P-fixation in acid tropical soils (Courley 1987, Olowolafe 2003). The decrease in effective cation exchange capacity after planting could be a result of absorption by plants, crop removal and leaching. Also, the value of the effective cation exchange capacity decreased due to reduction in the values of the exchangeable cations and exchangeable acidity since effective cation exchange capacity is the summation of the exchangeable cations and exchangeable acidity. Thus, the general increase in exchangeable acidity and effective cation exchange capacity from the surface soil to the deeper strata of the soil (subsoil) in the study site was probably due to leaching or infiltration of the exchangeable cations or their absorption by the potato crops for growth and yield and even the *Albizia lebbeck* trees. This agrees with the earlier observation made by Olowolafe & Dung (2000) in respect of soils derived from the biotite - granite on the Jos Plateau, Nigeria with regard to their nutrient status and management for sustainable agriculture.

Conclusions

Potato (*Solanum tuberosum* L.) can be productively and sustainably produced by employing the fresh foliage of the rattle tree (*Albizia lebbeck* Benth.) as green manure under alley cropping with this tree species. The optimal yield of this potato crop could be achieved by applying the green manure of the *A. lebbeck* at the 10 t ha^{-1} in the alleys (spaces) between the tree rows of this tree species two weeks prior to planting of the potato crops. The green manure should be incorporated in the soil (ploughed with the soil) so as to ensure proper and timely decomposition, mineralization and subsequent mobilization of nutrients to the companion crops (absorption / assimilation). Also, reasonable yield of this crop could also be obtained when the green manure of *A. lebbeck* is applied to farm land at rate of 5 t ha^{-1} two weeks prior to planting of the potato without the use of *A. lebbeck* tree rows and chemical fertilizer but soil/land conservation would be impaired or adversely affected without *A. lebbeck* tree rows with time (that is, there will be no continuous production on sustainable basis). Being a nitrogen fixing tree, this species is capable of improving the nitrogen status of the soil which could concomitantly lead to better fertility level of the soil in the long run. Thus, the overall cost of production will be drastically reduced, more so when the use of chemical or nitrogenous fertilizer is excluded.

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Uticaj albicije (*Albizia lebbeck* Benth.) na produktivnost krompira (*Solanum tuberosum* L.) na visoravni Jos u Nigeriji

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Sažetak: Poljski ogled je izveden na visoravni Jos u Nigeriji tokom pet vegetativnih sezona u cilju utvrđivanja uticaja redova zasada i zelenišnog đubriva drveta albicije (*Albizia lebbeck* Benth.) na prinos i produktivnost krompira (*Solanum tuberosum* L.). Ranostasna sorta krompira Bertita je korišćena u ogledu. Isklijale krtole su posađene u redovima zasada albicije dve nedelje nakon primene zelenišnog đubriva (5 i 10 t ha^{-1}). Uzorci zemljišta su analizirani pre i posle ogleda, a primenjena je redovna agrotehnika. Rezultati su pokazali da je drvo imalo značajan uticaj na parametre rasta krompira (visina biljke, broj listova, obim krtole (at $P < 0,01$)) i indekse prinosa (broj krtola ($P < 0,05$) i masa krtola ($P < 0,01$)) zbog hranljivih materija iz zelenišnog đubriva i aktivnosti fiksiranja azota. Primena zelenišnog đubriva albicije od 10 t ha^{-1} u redovima zasada albicije pokazala se kao najefektivniji tretman u pogledu rasta i optimalnog prinosa krompira.
Ključne reči: krtole, Albizia, zelenišno đubrivo, krompir, fiksiranje azota