Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.8, No.18, 2018 

# The Most Influential Morphological Growth Parameter Determining Potato (Solanum Tuberosum L.) Yiled Under Agroforestry System (Alley Cropping)

KAREEM, I. A.
Department of Plant Science & Biotechnology, Faculty of Science, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria

**Abstract**
Incontrovertibly, a reasonable number of morphological indices influence Irish potato (***Solanum tuberosum*** **Lin.)** yield. More often than not, some of these parameters (e. g. plant height, collar girth, leaf count) contribute positively to potato yield while a very few number of them (e. g. stem count stand$^{-1}$) negatively affect the yield in both rain-fed and irrigated cropping seasons under alley cropping. Thus, this experiment was conducted to know the most influential (external morphological) growth parameter that determines potato yield. The experiment was a completely randomized block design consisting of five treatments and three replicates for 5 cropping seasons within 3 years. Results from analysis of variance indicated significant differences among some morphological parameters on yield (at $P<0.01$). Correlation/ regression analyses indicated that collar girth had the highest positive correlation with yield ($r = 0.954$, $R^2 = 0.910$, $P < 0.01$) in rain-fed cropping seasons while leaf count recorded the highest positive correlation with yield during the irrigated cropping seasons ($r = 0.958$, $R^2 = 0.913$, $P < 0.01$) and in all the combined cropping seasons (from the simple correlation matrix, bi-variate /multiple Correlation/ regression analyses). Therefore, it was confirmed that leaf count was the most influential/main determinant of potato yield under alley cropping (an agroforestry system).
**Keywords:** morphological parameters, alley cropping, determinant, potato yield

## 1.0 INTRODUCTION

Alley cropping is a form of agroforestry system which connotes planting of annual/herbaceous crop(s) in the spaces /alleys between the hedgerows of perennial trees (mostly leguminous/nitrogen fixing) which paves way for multiple harvests of products and enables the land remain productive/sustainable perpetually. Agroforestry entails multiple land use system which involves the production of both perennial forest tree crops, annual (agronomic) crops and animals (in some cases) on the same land management unit either simultaneously or sequentially (Kareem, 2008).The international council for Research in Agroforestry (ICRAF, 1983) defined agroforestry as a collective name for land use systems and practices where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land management unit as agricultural crops and / or animals, either in some form of spatial arrangement or temporal sequence.

The rattle tree *(Albizia lebbeck* Benth) which is in the family mimosacea, originated from India (Prinsen, 1986) and had also naturalized in many tropical and sub-tropical regions of the world such as North Africa, the West Indies, South America and South East Asia (Streets, 1962). It is medium sized tree and very prolific in terms of seed production and can be propagated by seeds, stem and root cuttings with vigorous growth rate (NFTA, 1988; Kareem *et.al*., 2005a & b) though the seeds exhibits dormancy prior to germination/seedling emergence (Kareem, 2001). It is a renowned tree in the spheres of nodulation and nitrogen fixation (Kadiata et. al., 1996) and has numerous uses including soil fertility improvement, forage/fodder, timber/poles, as ornamental tree and for apiculture.

Irish potato *(Solanum tubersum* Lin.) in the family Solanaceace had its native place from the 'Altiplano around the Lake Titicaca at an attitude of about 300m in the Bolivian Andes' (Burton, 1966; Kay, 1987 ) or from South America and introduced into the Jos Plateau - Nigeria in the later part of 19$^{th}$ century and early 20$^{th}$ century (Ifenkwe, 1981). The benefits from potato include potato crisps, chips, potato starch/fiour and as animal feed.

The objective of this research is to know the most influential (external) morphological growth parameter that determines potato yield during the five cropping seasons under alley cropping.

## 2. 0 MATERIALS AND METHODS

This study was carried out in the Jos Plateau, Nigeria (between Latitude $8^0$ $50^1$ N and $10^0 10^1$N, longitude $8^0$ $22^1$E and $9^0$ $30^1$ E , average elevation is above 1250m above sea level, the climate is characterized by rainy and dry seasons, lowest minimum temperatures occur in December and January which are $14.74^0$ and $14.24^0$ while the highest mean maximum temperature ($33.3^0$C) occurs in April (Udo, 1978). This agroforestry (alley cropping) experiment was a randomized complete block design (RCBD) comprising 5 treatments and 3 replicates. The mini- plots within and outside each block were assumed to be homogenous and heterogenous respectively owing to possible fertility gradient in the site.

The treatments applied during the rainy and dry seasons were the same and they are :$T_0$:Potato planted on flat bed without tree rows and green manure of *Albizia lebbeck* (control), $T_1$: Potato planted in the alleys (spaces) between *A. lebbeck* tree rows without green manure, $T_2$: Potato planted without tree rows of *A. lebbeck* but with green manure at 5 ton $ha^{-1}$ , $T_3$:Potato planted in the alley of *A. lebbeck* tree rows with its foliage as leaf mulch at 5 ton $ha^{-1}$ not incorporated into the soil and $T_4$:Potato planted in the alleys of *A. lebbeck* tree rows with its green manure incorporated into the soil at land preparation at 10 ton ha-[1]. Plot size was 3m x 2m, single application of *A. labbeck* foliage (as mulch) and green manure were done two weeks before planting where required in certain treatments, pre- sprouted potato tubers were planted to ensure uniform germination/emergence, 3 rows of potato plants per plot (65cm between rows and 25cm within rows) and planting depth was 8- 10cm. *A. lebbeck* tree rows (seedlings raised were 6 months old prior to transplanting) were 0.6m and 2.0m within and between rows respectively at both sides of each of the plots (each space/alley where potato tubers were planted was approximately $6m^2$ and embankment was constructed between adjacent mini-plots to prevent any mini - erosion and any possible flow of nutrients from one plot to another. Throughout the 5 cropping seasons (3 rainy and 2 dry seasons), tending operations were adequately carried out [e. g. watering (during dry seasons only), weeding, pest control (especially rodents), fire tracing (during dry seasons), mini-erosion control (during rainy season) and shade (of *A. lebbeck*) reduction at the 3rd, 4th and 5th cropping seasons].

The morphological parameters assessed were plant height, number of leaves (leaf count), number of stem (stem count) per stand and collar girth while the yield parameters include tuber count and tuber yield /weight in ton $ha^{-1}$(Table 1). Also, prior to the measurement of the growth and yield indices, the potato seedlings' emergence rates and percentages were evaluated. The frequency of irrigation was every 2 days, soil moisture was maintained at field capacity during tuber initiation, tuberization (tuber formation) and bulking but reduced to 50% at maturation. Irrigation (during season cropping) continued till 7 days to harvest and about 500 – 600mm was applied (King *et. al*., 2003). Data collected were subjected to statistical analysis of variance technique (ANOVA), DMRT, SAS and SPSS 11.0 were employed where needed/appropriate.

**3.0 Results and Discussion**

The Simple correlation analysis indicated that all the morphological parameters (except Stem Count) were positively correlated with Tuber Yield in both the rain fed and irrigated cropping seasons and in the combined seasons (Tables 2-4). Stem Count was strongly negatively correlated with Tuber Yield (r -0.891) in both seasons and in the combined seasons. The Stem Girth had the highest positive correlation to Tuber Yield in the rain fed /wet Season cropping (significant at P= 0.01). For the irrigated (dry season) cropping, leaf count was the parameter that was most positively correlated to Tuber Yield (significant at P= 0.01) and it also emerged as the most positively correlated (to tuber yield) in the combined seasonal effects analysis

The above observations were confirmed in both the bivariate and multiple Correlation/Regression Analyses done on the data set (Tables 2-4). In the bivariate correlation analysis for the Rain-fed (Wet Season) cropping, all the growth parameters (except Stem Count) were significantly/ positively correlated to Tuber Yield at P= 0.05 but only the Stem Girth was significant at P=0.01. The Stem Count was negatively correlated to Yield, significant only at P= 0.05. The trend was not the same for Irrigated (Dry Season) cropping sequel to the fact that it was the Leaf Count (not the Stem Girth) that had highest value in terms of significant/positive correlation with Yield at P=0.01. For the Combined Seasons' Analysis, the trend was different, only the Leaf Count had significant correlation with yield at 0.01; other growth parameters had positive correlation with yield (at P= 0.05).

The multiple correlation /regression analyses confirmed the trend indicated by the bivariate correlation analysis. For the rain-fed cropping, the Stem Girth had the highest impact on yield (significant at 0.01 and with a p- value of 0.012). The Leaf Count was the most influential parameter on yield in the irrigated cropping (Significant at 0.01 and with p value of 0.011) and was observed to have the highest positive effect on yield in the combined seasons' Analyses (Significant at 0.01 with a p value of 0.02, Table 4).

 

**Table 1: Seedling emergence percentage, growth and yield parameters of Irish potato in the 1st, 2nd, 3rd 4th and 5th cropping season.**

| Treatmentss | | Growth Parameters | | | | | Yield Parameter | |
|---|---|---|---|---|---|---|---|---|
| (5) | %S.E. 7DAP | %S.E 14DAP | Plant Ht | Leaf Count | Stem Count | Collar Girth | Tuber Count | Tuber Yield |
| 1st Season | | | | | | | | |
| T0 | 70.0a | 97.0a | 44.7d | 24.7d | 3.0a | 2.2e | 112.3c | 5.03d |
| T1 | 52.06b | 98.0a | 51.3c | 27.0d | 2.7ab | 2.8d | 109.0c | 5.08d |
| T2 | 41.0c | 97.0a | 53.7c | 41.3b | 2.3ab | 3.07c | 139.0b | 8.36b |
| T3 | 62.0ab | 97.7a | 55.7b | 35.7c | 2.3ab | 3.4b | 113.0c | 7.98c |
| T4 | 57.3b | 99.0a | 66.3a | 56.7a | 2.0b | 4.5a | 160.7a | 9.36a |
| 2nd Season | | | | | | | | |
| T0 | 29.7b | 92.7ab | 48.0e | 30.0c | 2.3b | 2.3e | 79.7d | 5.19e |
| T1 | 24.3c | 90.0ab | 55.7d | 35.0c | 2.7a | 3.0d | 111.0c | 5.43d |
| T2 | 24.0c | 87.0b | 58.7c | 53.0b | 3.0a | 3.4c | 153.7a | 9.72b |
| T3 | 33.7a | 87.7b | 62.3b | 52.0b | 2.3b | 3.5b | 127.7b | 8.90c |
| T4 | 24.7c | 95.0a | 68.3a | 67.3a | 3.0a | 4.7a | 160.7a | 10.41a |
| 3rd Season | | | | | | | | |
| T0 | 58.3b | 94.7b | 62.0c | 36.7d | 3.0a | 2.4e | 92.3c | 5.30e |
| T1 | 54.7b | 98.3a | 65.0bc | 52.3c | 3.0a | 3.3d | 94.7c | 5.40d |
| T2 | 43.7c | 98.0a | 67.7b | 61.7b | 3.0a | 3.6c | 151.7a | 9.13b |
| T3 | 71.7a | 97.7ab | 63.7c | 64.0b | 2.7a | 3.5b | 118.0b | 8.61c |
| T4 | 56.7b | 97.0ab | 75.3a | 70.3a | 2.7a | 4.9a | 93.7c | 9.80a |
| 4th Season | | | | | | | | |
| T0 | 36.3b | 93.0ab | 64.7d | 44.0e | 3.0a | 2.5e | 95.7bc | 5.22d |
| T1 | 31.0c | 92.0b | 70.3c | 60.0d | 3.0a | 3.5d | 93.7c | 5.74c |
| T2 | 29.0c | 95.0ab | 76.3b | 66.0c | 2.0b | 4.3b | 142.7a | 9.61a |
| T3 | 33.0bc | 84.0c | 74.3b | 72.3b | 2.3b | 4.1c | 103.3b | 8.90b |
| T4 | 41.0a | 97.0a | 80.7a | 77.7a | 2.3b | 5.3a | 87.0d | 9.73a |
| 5th Season | | | | | | | | |
| T0 | 61.0a | 93.0a | 63.7d | 46.0c | 2.7a | 3.1e | 97.0c | 5.28e |
| T1 | 55.3a | 91.7a | 70.7c | 72.3b | 2.7a | 3.5d | 91.0c | 5.85d |
| T2 | 59.0a | 92.3a | 77.3b | 71.0b | 2.3a | 4.4b | 160.7a | 9.63b |
| T3 | 59.3a | 94.0a | 71.3c | 70.3b | 2.7a | 4.2c | 142.7b | 9.02c |
| T4 | 63.0a | 94.0a | 82.3a | 78.7a | 2.3b | 5.3a | 161.7a | 11.96a |

S.E. =Seedling Emergence, DAP = Day After Planting, mean values with the same letters were not significantly different at 5% level by Duncan's Multiple Range Test (DMRT)

Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.8, No.18, 2018 

Table 2: Correlation Matrix for the Morphological and Yield Parameters of Potato

| | Y | X1 | X2 | X3 | X4 |
|---|---|---|---|---|---|
| Rain Fed (Wet Season) Cropping | | | | | |
| Y | 1.000 | | | | |
| X1 | 0.881* | 1.000 | | | |
| X2 | 0.905* | 0.955* | 1.00 | | |
| X3 | -0.891* | -0.898* | -0.803* | 1.000 | |
| X4 | 0.954* | 0.970** | 0.956** | -0.941** | 1.000 |
| Irrigated (Dry Season) Cropping | | | | | |
| Y | 1.000 | | | | |
| X1 | 0.911* | 1.000 | | | |
| X2 | 0.956** | 0.981** | 1.000 | | |
| X3 | -0.573. | -0.300. | -0.471. | 1.000 | |
| X4 | 0.897* | 0.984** | 0.965** | -0.246. | 1.000 |
| Combined Season | | | | | |
| Y | 1.000 | | | | |
| X1 | 0.720. | 1.000 | | | |
| X2 | 0.938** | 0.866* | 1.000 | | |
| X3 | 0.052. | 0.053. | 0.193. | 1.000 | |
| X4 | 0.785. | 0.977** | 0.873* | -0.126. | 1.000 |

** Significant at 0.01, * Significant at 0.05, ·Not Significant.
Variable Description: Y = Tuber Yield in t/ha (the Dependent Variable); X1 to X4 = the Independent Variables: X1 – Plant Height, X2 – Leaf Count, X3 – Stem Count, X4 – Stem Girth.

Table 3: Bivariate Correlation/Regression Analyses: morphological Parameters Vs Potato Yield

| Variables | | Correlation Coefficient 'r' | Intercept 'a' | R2 | P Value |
|---|---|---|---|---|---|
| Rain Fed (Wet Season) Cropping | | | | | |
| Y | X1 | 0.881* | 0.310 | 0.777 | 0.048 |
| | X2 | 0.905* | 0.173 | 0.820 | 0.034 |
| | X3 | -0.891* | -5.982 | 0.794 | 0.043 |
| | X4 | 0.954** | 2.308 | 0.910 | 0.012 |
| Irrigated (Dry Season) cropping | | | | | |
| Y | X1 | 0.911* | 0.304 | 0.830 | 0.031 |
| | X2 | 0.958** | 0.150 | 0.913 | 0.011 |
| | X3 | -0.573. | -6.314 | 0.328 | 0.313 |
| | X4 | 0.897* | 2.313 | 0.804 | 0.039 |
| Combined Season | | | | | |
| Y | X1 | 0.720. | 0.036 | 0.519 | 0.170 |
| | X2 | 0.938** | 0.036 | 0.881 | 0.018 |
| | X3 | 0.052. | 0.148 | 0.003 | 0.933 |
| | X4 | 0.785. | 1.040 | 0.616 | 0.116 |
| | | | | | |

** Significant at 1%, *Significant at 5% Variable Description: Y = Crop Yield (t/ha), $X_1$ – $X_4$ = Independent variables. $X_1$ =Plant Height, $X_2$ =Leaf Count, $X_3$ = Stem Count, $X_4$ = Collar Girth, a =Intercept [the part the of the dependent variable (yield) that does not change or vary with change in the independent variable (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.

Journal of Biology, Agriculture and Healthcare www.iiste.org
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.8, No.18, 2018

Table 4: Multiple Correlation/Regression Analyses: External Morphological Growth Parameters versus Yield of Potato

| Variables | Intercept 'a' | Std Error | Multiple R | $R^2$ | F-value | P –value |
|---|---|---|---|---|---|---|
| Rainf fed (Wet Season) Cropping | | | | | | |
| X1 | 0.310 | 0.096 | 0.881 | 0.777 | 10.450 | 0.048* |
| X2 | 0.173 | 0.047 | 0.905 | 0.820 | 13.653 | 0.034* |
| X3 | -5.982 | 1.761 | -0.891 | 0.794 | 11.540 | 0.0426* |
| X4 | 2.308 | 0.419 | 0.954 | 0.910 | 30.424 | 0.012** |
| Irrigated (Dry Season) Cropping | | | | | | |
| X1 | 0.304 | 0.080 | 0.911 | 0.830 | 14.645 | 0.031* |
| X2 | 0.150 | 0.027 | 0.956 | 0.913 | 31.631 | 0.011** |
| X3 | -6.314 | 5.214 | 0.573 | 0.328 | 1.467 | 0.313 |
| X4 | 2.313 | 0.659 | 0.897 | 0.804 | 12.335 | 0.039* |
| Combined Cropping Season | | | | | | |
| X1 | 0.036 | 0.020 | 0.720 | 0.519 | 3.231 | 0.170 |
| X2 | 0.036 | 0.008 | 0.720 | 0.881 | 22.120 | 0.018* |
| X3 | 0.148 | 1.623 | 0.052 | 0.003 | 0.008 | 0.933 |
| X4 | 1.039 | 0.474 | 0.765 | 0.616 | 4.809 | 0.116 |

** Significant at 1%, *Significant at 5%, Variable Description: Y = Crop Yield (t/ha) , $X_1$ – $X_4$ = Independent variables. $X_1$ =Plant Height, $X_2$ =Leaf Count, $X_3$ = Stem Count, $X_4$ = Collar Girth, a = Intercept [the part the of the dependent variable (yield) that does not change or vary with change in the independent variable (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.

The high level of bivariate correlation between potato collar girth and yield (r = 0.954) at 1% level of significance connotes that the potato plants with high values of collar girth produced larger tubers corresponding to higher yield. This was exactly what was discovered during harvest in all the five cropping seasons. Those stands with 3-5 stems (i. e. at a point) had lower tuber weight/yield due to smaller sizes of the tubers per stem as opposed to stands with 1-2 stem(s) which had bigger sizes of potato tubers which resulted in higher tuber weight/yield. Amadi *et. al*. (2005) made a similar observation regarding the negative/significant correlation between number of tubers per plant and average tuber weight. There was also positive relationship between stem count and tuber count. This means that each of the stems per plant produced a tuber (Irish potato being a stem tuber) thus making the tuber count higher (Kareem, 2008) but due to the fact that the sizes of those tubers were small, tuber weight/yield was correspondingly low especially where soil nutrient status was low (where there was no green manure/mulch application/ *A. lebbeck* nitrogen fixing tree).

Similarly, plant height and leaf count were positively and significantly correlated in the rain-fed and irrigated cropping seasons (Tables 2- 4). This means that potato plants with higher values of plant height had more leaves which brought about increased surface area for photosynthesis which led to increased accumulation of photosynthates which enhanced tuber formation as a result of assimilation (after nutrient absorption) which eventually culminated in high tuber yield though it required an optimal number of leaves or leaf area index to optimize tuber yield (Fomba, 1998; Lopez *et. al*., 1987; *Amadi et. al.,* 2005).The significant effects recorded on multiple correlation and regression analyses in respect of the morphological parameters versus yield in both rainy and dry season croppings indicated a high influence of the independent variables (growth/morphological parameters) on the dependent variable (crop yield). Apart from stem count which had a negative correlation and regression coefficient with yield, all the remaining growth parameters positively correlated with yield (Tables 2-4).

These phenomena showed that the more the stem count per plant or stand the more the tuber count but lesser the tuber size/weight though subject to soil fertility status and other factors such as disease attack (Kareem, 2014b) and level of competition by weeds. Since potato is a stem tuber crop, more stems bring about more tuber count which has negative correlation with tuber weight due to small sizes of the tubers. Amadi *et. al*. (2005) observed a negative correlation between tuber count and tuber yield and even if the soil fertility status is high the tuber can only increase to a maximum value (limit) with increasing stem density (Allen and Wurr, 1992). Most of the stands of this potato (bertita variety) under study in $T_0$ and $T_1$ which had lower nutrient status owing non - incorporation of *Albizia lebbeck* green manure had lower tuber weight /yield irrespective of their tuber count due to the small nature of their tubers. In the rain-fed cropping, collar girth had the highest bivariate correlation coefficient (r) and the intercept 'a' probably due to the fact that it had the highest $R^2$ value (0.910) at 1% (Tables 2 -4). Besides this, collar girth of potato stems in $T_4$, $T_2$ and $T_3$ with green manure of the rattle tree which brought about high nutrient status had higher values of collar girth and tuber weight/yield, as opposed to smaller stem girth in $T_0$ and $T_1$ with corresponding smaller tuber sizes and low tuber weight / yield. Thus, collar girth accounted for 91.0% of variation in tuber yield in the rain-fed planting season.

Unlike the rainfed cropping season, leaf count recorded the highest value of coefficient of determination ($R^2$), correlation coefficient (r) and level of significance in the irrigated cropping (dry season) which were 0.913, 0.956 and 0.011 respectively (Tables 2 - 4).This was probably due to effect of leaf count on tuberization (tuber formation) and subsequent tuber weight / yield. Large leaf area index is a function of leaf count which paved way for increased photosynthetic activities and subsequent build-up / anabolism / assimilation / accumulation of photosynthates for tuber formation (Kareem, 2014b). It accounted for 91.3% of the variation in potato yield at 1% level. Similarly, leaf count also recorded the highest value of coefficient of determination and level of significance in the combined cropping seasons which were 0.881 and 0.018 respectively (Table 2). This trend as earlier opined could be due to the vital roles of leaves in crop growth, development and yield (Fomba, 1998; Amadi *et. al*., 2005) with regard to photosynthesis, assimilation of photosynthates and subsequent tuber formation and yield.

**4.0 Conclusion and Recommendation**

It was evident from this study that all the morphological/apparent growth indices (with the exemption of stem count) reasonably/positively influenced the crop (Irish potato: bertita variety) yield but the most positively influential was the leaf count (number of leaves) in all the data analyses from dry season/irrigated croppings and combined seasons. As earlier mentioned, other apparent growth indices (e. g. collar girth, plant height) had strong positive correlation with yield apart from stem count per stand which negatively affected the tuber weight/yield Therefore, it is hereby recommended that efforts should be geared towards having improved nutrient status in the alleys which can ensure effective growth and development of the potato plants. This will eventually pave for proper/optimal leaf production for larger leaf area for anabolic processes (e. g. photosynthesis) which will ultimately lead to higher yield.

**5.0 References**

1. Amadi, C. O.; Ene-obong, E. E. and Okonkwo, J. C. (2005). Correlation and Regression Analyses of Yield and Yield Components of Potato in Jos Plateau, Nigeria. *Proceedings of the 39th Annual Conference of the Agricultural Society of Nigeria* Held in the University of Benin, Benin City Nigeria. In: Orheruata, A. M. Nwokoro, S.O; Ajayi, M. T.; Adekunle, A. T. and Asumugha, G. N. (eds.). pp 364 -367.
2. Allen, E. J. and Wurr, D. C. (1992). *Plant Density.* In: The Potato Crop (P. M. Harris ed.). Chapman and Hall London pp. 292 – 330.
3. Burton. W. G. (1966). *The Potato. A Survey of Its History and Factors Influencing its Yield, Nutritive Value, Quality and Storage*. 2nd Ed. Wageningen, Netherlands: European Association for Potato Research, 382 pp.
4. Fomba, V. N. (1998). Effects of *Gliricidia sepium* Leaf Mulching Time as Green Manure on the Growth and Yield of Okra. Unpub. M.Sc. Thesis. Dept. of Forest Resources Management, Faculty of Agric. and Forestry, University of Ibadan, Ibadan – Nigeria. Pp 16 – 58.
5. ICRAF (1983). A Global Inventory of Agroforestry Systems: A Project Announcement. *Agroforestry Systems* 1: 269 – 273.
6. ICRAF (1986). An Introduction to Agroforestry Diagnosis and Design. In: J.B. Raintree ed. With Contributions from ICRAF Multidisciplinary Staff. P.O. Box 30677, Nairobi – Kenya p.6
7. Ifenkwe, O. P. (1981). A Review of the Status of Potato Production in the Plateau State of Nigeria pp 1 – 2.
8. Kadiata, B. D.; Mulongoy, K. and Isirimah, N. O. (1996). Time Course of Biological Nitrogen Fixation, Nitrogen Absorption and Biomass Accumulation in Three Woody Legumes. IITA P.M.B. 5320 Ibadan, Nigeria. Biological – *Agriculture and Horticulture* 1996, 13:3, 253 – 266.
9. Kareem, I. A.; .Adedeji, T. A. and Usman, M. B. (2001).Pre-treatment Effects on the Germination and Early Growth of *Albizia lebbeck* Benth and its Potential as Livestock Feed. *The Antenna: Journal of Science and Technology* 1 (1): 48-53(Nigeria).
10. Kareem, I. A.; Adepetu, A. A.and Olowolafe, E. A. (2014a): Rattle Tree *(Albizia lebbeck* Benth) Effects on potato (*Solanum tuberosum* Linn.) Productivity on the Jos Plateau, Nigeria. *Journal: Field and Vegetable Crops Research.* 51 (2):116-126 ( Sebia).
11. Kareem, I. A. (2014b): Comparative analysis of seasonal effects on the growth performance and yield of potato (*Solanum tuberosum* Lin.) under agro -forestry system (alley cropping) with the rattle tree (*Albizia lebbeck Benth*). Journal *of Biology, Agriculture and Healthcare* 4 (25): 39-50 (USA).
12. Kareem, I. A. (2015a).Soil chemical properties as influenced by *Albizia lebbeck* Benth (rattle tree) under agri-silvicultural system (alley cropping) with *Solanum tuberosum* Lin. (potato).*Donnish Journal of Horticulture and Forestry*1(1): 1- 11 (UK).
13. Kareem, I. A. and Akindele, O. (2015b). Evaluation of the responses of *Solanum melogena* to different soil types and levels of NPK fertilizer. *Donnish Journal of Agricultural Research* (DJAR) Manuscript Number DJAR – 2015 – 1082(6): 048 – 054. (UK).

14. Kareem, I. A. and Adegoke, A. O. (2015c).Response of *Glycine max* (soybean) to different soil types and levels of NPK fertilizer. *International Journal of Agricultural Research and Review* (IJARR) 3(7): 356-358 ( Nigeria).
15. Kareem, I. A.(2017):Impact of A*lbizia lebbeck* Benth on soil nutrient status and crop yield under agroforestry system (alley cropping). Published Proceedings of the 9$^{th}$ ISTEAMS International Multidisciplinary Conference at the University of Ghana, Legon, Accra, Ghana, 25$^{th}$ – 27$^{th}$ October, 2017, pp. 231 – 240.
16. Kay, D. E. (1987). Potato (*Solanum tuberusum).* Tropical Development and Research Institute. 127 Derkenwell Road, London ECIR 5DB Overseas Development Administration. 308 pp.
17. King, B.; Stark, J. and Love, S. (2003). Potato Production with Limited Water Supplies. Paper Presented at Idaho Potato Conference on 22$^{nd}$ January, 2003 pp. 45 – 54.
18. Lopez, D. F.; Boe, A. A.; Johansen, R. H. and Jansky, S. H. (1987). Genotype X Environment Interaction, Correlations and Combing Ability of Six Traits in Potato (Abstract) *American Potato Journal* 64:447.
19. Prisen, J. H. (1986). Potential of *Albizia lebbeck (Mimosaceae*) as a Tropical Fodder Tree – A Review of Literature. *Tropical Grasslands* 20(2): 78-83.
20. Streets, R. (1962). Exotic Forest Trees in the British Commonwealth Clarendon Press Oxford pp. 169- 170
21. Udo, R. K. (1978). Geographical Regions of Nigeria. Ibadan; London: Heinemann pp. 1 - 14