

Growth Assessment, Grain and Fodder Yield Potentials of Sunflower (*Helianthus Annuus L.*) Under Varying Phosphorus Rates in Southern Borno, Nigeria

Wabekwa, J. W.

Department of Crop Production,
University of Maiduguri, Nigeria

Dangari, L. C.

Department of Agric. Technology,
Adamawa State College of Agriculture,
Ganye, Nigeria

Kamai, N.

Department of Crop Production,
University of Maiduguri, Nigeria
Email: nkekikamai@yahoo.com

Abstract – Field experiments were conducted during successive rainy seasons of 2010 and 2011 at Wamdeo South of Borno State (100 30' N, 130 09'E), 523 m above sea level in Sudan-Northern Guinea savanna transition of Nigeria. This was to study the performances of yield parameters, yield components and some yield contributing growth parameters under various phosphorus rates (0, 20, 40, 60 and 80 Kg P₂O₅ ha⁻¹). The treatments were laid in randomized complete block design and replicated three times. Results showed that phosphorus application did not influence physiological growth parameters during most of the first sampling periods. Leaf area per plant increased with higher and statistically similar values recorded among 60-80 Kg P₂O₅ ha⁻¹ during most of the sampling periods. Similarly, the application of 60-80 Kg P₂O₅ ha⁻¹ recorded higher and statically similar crop growth rates during most of the sampling periods, as results were not statistically significant in 2010 (6 WAS), 2011 (8 and 10 WAS), and two years mean (6 and 10 WAS). Dry matter production also increased with increasing phosphorus application with statistical similarities among 40-80 Kg P₂O₅ ha⁻¹ during most of the sampling periods, except at 6 WAS during 2011 rainy season. Data on yield components showed that days to 50% flowering reduced statistically with increasing P₂O₅ rates up to 60 Kg ha⁻¹ in 2011 rainy season and the two years combined means averaging 75.13 days. Similarly, increasing P₂O₅ rates to 60 Kg ha⁻¹ increased head dry weight in the two years mean (89.62g), and the performance of 1000-grain weight during 2011 rainy season. However, 20-80 Kg P₂O₅ ha⁻¹ recorded similar values for 1000-grain weight in 2010 and the two years mean. Phosphorus application also influenced yield parameters as 40-80 kg P₂O₅ ha⁻¹ increased grain yield with yield value for the two years mean averaging 2114.60 Kg ha⁻¹ at 40 Kg P₂O₅ ha⁻¹, which could be the recommended rate for seed growers in the study area. Similarly, application of 60 Kg P₂O₅ ha⁻¹ statistically increased fodder yield with average value of 2546.20 Kg ha⁻¹ recorded in the two years mean, which could be the recommended rate for optimum fodder yield benefit among sunflower growers in the study area. Conclusively, therefore, sunflower seeds and haulms can complement Nigeria's traditional edible oil and the off-season availability of dry fodder for livestock use respectively.

Keywords – Northern Guinea Savanna, Phosphorous, Sunflower and Yield.

I. INTRODUCTION

Sunflower seeds may soon be a potential complementary crop to Nigeria's indigenous edible oil derived from groundnuts, oil palm and sesame seeds; and this is because its cultivation is locally spread as its seeds has gained faster popularity for its edible virtues for

human either in its fried or boiled form, or administered row as livestock feed. The use of sunflower haulms and straws as roughages for livestock is also gaining faster popularity among local Nigerian farmers. Presently however, its cultivation has unfortunately been limited by poor agronomic practices and low soil inherent nitrogen and phosphorus, and the two are most essential for sunflower yield performances. Phosphorus has been described by [1] as most important element required by plants for growth, seed formation and good yield because it positively affects photosynthetic rates and radiation use efficiency [2] also reported that phosphorus is involved in cell division, development of root system and energy transfer in plants. Furthermore, studies by [3] revealed that phosphorus is essential for inflorescence, grain formation and grain ripening; and [4] reported that the potentials for improving seed set and seed filling in crops seems to be mainly associated with increased phosphorus assimilates. Reference [5] indicated that it takes longer time for insoluble phosphate compound to release its locked up phosphorus.

The effects of inorganically supplied phosphorus on sunflower performances have been reported by several researchers. For example, [6] reported significant increase in seed filling and reduction in number of days to 50% flowering with P₂O₅ application at increasing rates. Reference [7] also reported that the application of 60 Kg P₂O₅ ha⁻¹ increased dry matter production due to increased respiration and photosynthetic ability; and further added that during early growth phase, P₂O₅ rates have no significant effects on leaf area. Reference [8] recorded higher values for plant heights, crop growth rates, leaf area and number of leaves per plant at increasing P₂O₅ rates up to 120 Kg ha⁻¹. Other reporters include [9] and [10] who recommended 60 Kg P₂O₅ ha⁻¹; and [11] whose recommendation was 80 Kg P₂O₅ ha⁻¹, all for optimum grain yield. For fodder yield, [12] reported similar P₂O₅ rate of 80 Kg ha⁻¹, and contending report from [13] (2000) indicated that 1000 – grain weight, head dry weight and days to 50% flowering were not significantly influenced by P₂O₅ rates.

Nitrogen management studies have been conducted in several agroecological zones where sunflower have been tested to adapt. However, except for reports from Ibadan, Southern Guinea savanna [14] and from Samaru, Northern Guinea savanna by [7]), studies on phosphorus mineralization for sunflower performances have not been conducted in recent times, especially in the dry Savanna

agroecology. Thus there is the need therefore to conduct this study in order to make recommendations which will help increase yield performances in the study area.

II. MATERIALS AND METHODS

Two field trials were conducted during 2010 and 2011 rainy seasons at Wamdeo (100 30' N, 130 09'E), 523 m above sea level, located South of Borno State. The study scope forms part of Sudan-Northern Guinea savanna agroecological zone transition in Nigeria. This was to study the effects of phosphorus fertilizer rates supplied inorganically on yields and yield components, and on some physiological growth parameters contributing to yields in sunflower. The treatments consisted of 0, 20, 40, 60 and 80 Kg P₂O₅ ha⁻¹ and the experimental design was randomized complete block design (RCBD), replicated three times.

Experimental field was cleared, ploughed, harrowed, levelled, and laid out, and the above treatments (SSP) was incorporated by broadcasting during land preparation at their appropriate rates in order to achieve its desired efficacy. Seeds were obtained from the Plant Science Department of Ahmadu Bello University, Zaria, and handsown at 75cm x 25cm in mid-June during both trial seasons, following heavy rainfall. Seedlings from over-seeded holes were thinned to one plant stand per hole during first weeding (2 WAS) and this gave total plant population of 53,333 plant/hectare. Further weed management and other necessary agronomic practices

were carried out and earthing up of plant base was done as last weeding operation (10 WAS) in order to minimize yield loss to lodging, which might later occur due to increased head weight and diameter.

Data on physiological growth parameters were taken from identified plant stands, fortnightly (2 WAS) and terminated at plants physiological maturity which was morphologically determined by seizure in leaf production and senescence; and the production of terminal florets. Number of days to 50% flowering were recorded as the days interval between seed sowing to the period of production of terminal ray disc flowers by exactly 50% total plant stands in each plot. Head dry weight, 1000-grain weight; grain and fodder yields were all evaluated from net plots at harvest. Data analysis were carried out using the analytical software, "statistix" version 8.0, and mean separation was done using Duncan's multiple range test [15] at 5% confidence level.

III. RESULTS

Table 1 show that results on the effects of phosphorus rates on leaf area (LA) per plant in sunflower were not statistically significant in both years and combined analysis at 4 WAS. However, results from 6, 8 and 10 WAS sampling shows that application of 60 and 80 Kg P₂O₅ ha⁻¹ produced similar results which statistically out-measured lower P₂O₅ rates during the two years and their combined means.

Table 1: Assessment of Leaf Area per plant (LA) in Sunflower as influenced by Phosphorus levels in Southern Borno, Nigeria, during 2010-2011 rainy seasons and the two years means

P ₂ O ₅ (kg ha ⁻¹)	Leaf area (cm ²)/plant											
	4 WAS ¹			6 WAS			8 WAS			10 WAS		
	2010	2011	Mean ²	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
0	5.91	5.92	5.91	13.53 ^{c3}	12.92 ^b	13.23 ^c	22.22 ^c	17.37 ^c	19.79 ^d	24.57 ^c	21.47 ^c	23.02 ^c
20	5.83	5.09	5.46	13.90 ^{bc}	13.91 ^{ab}	13.91 ^{bc}	21.67 ^c	19.17 ^b	20.42 ^{cd}	25.11 ^{bc}	22.30 ^c	23.71 ^{bc}
40	5.90	5.15	5.52	14.95 ^{ab}	13.32 ^b	14.13 ^{bc}	24.23 ^b	19.49 ^b	21.86 ^{bc}	26.43 ^{a-c}	22.72 ^{bc}	24.57 ^b
60	6.16	5.22	5.80	15.73 ^a	13.95 ^{ab}	14.84 ^{ab}	24.49 ^{ab}	20.24 ^{ab}	22.36 ^{ab}	26.58 ^{ab}	23.77 ^{ab}	25.18 ^{ab}
80	6.69	5.44	5.90	16.22 ^a	14.86 ^a	15.54 ^a	29.19 ^a	21.39 ^a	23.79 ^a	28.36 ^a	24.48 ^a	26.42 ^a
SE (±)	0.432	0.430	0.331	0.691	0.645	0.512	0.976	0.882	0.889	0.979	0.639	0.763

1. Week after sowing

2. Mean value of the means for the two years for 2010 and 2011 data

3. MEAN in a column followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT

Results from Table 2 similarly indicated that the effects of phosphorus rates on dry matter production was not significant in both years and their combined means at 4 WAS. Results from the remaining sampling periods for 2010, 2011 rainy seasons and their combine mean however recorded higher and statistically similar values among 40, 60 and 80 Kg P₂O₅ ha⁻¹ except in 2011 (6 WAS).

Data on Table 3 also shows the effects of phosphorus rates on crop growth rates (CGR) in sunflower. Results indicate that crop growth were accelerated by increased phosphorus application up to 60 and 80 Kg P₂O₅ ha⁻¹ at 6 WAS in 2011 and at 8 and 10 WAS in 2010 rainy seasons. Growth values for the two years mean at 8 WAS were also statistically similar across all phosphorous rates, except 80 Kg P₂O₅ ha⁻¹ and results were not statistically significant during the rest of sampling periods.

Table 2: Assessment of Plant dry weight in Sunflower as influenced by Phosphorus levels in Southern Borno, Nigeria, during 2010-2011 rainy seasons and the two years means

P ₂ O ₅ (kg ha ⁻¹)	Plant dry weight (g)											
	4 WAS ¹			6 WAS			8 WAS			10 WAS		
	2010	2011	Mean ²	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
0	16.12	8.73	12.42	60.99 ^{b3}	45.32 ^{bc}	53.16 ^b	150.20 ^{ab}	101.79 ^{bc}	125.99 ^{ab}	198.17 ^b	134.00 ^{bc}	166.09 ^c
20	16.31	8.69	12.50	66.21 ^{ab}	41.15 ^c	53.68 ^b	140.16 ^b	93.33 ^c	116.75 ^b	207.88 ^{ab}	124.27 ^c	166.08 ^c
40	16.73	9.49	13.11	70.31 ^{ab}	42.77 ^c	56.54 ^{ab}	148.51 ^{ab}	103.69 ^{a-c}	126.10 ^{ab}	213.56 ^a	138.63 ^{a-c}	176.10 ^{ab}
60	16.64	10.72	13.68	72.63 ^a	52.59 ^{ab}	62.61 ^a	151.13 ^a	109.07 ^{ab}	130.10 ^{ab}	212.80 ^a	143.97 ^{ab}	178.38 ^{ab}
80	18.46	10.94	14.70	75.44 ^a	54.40 ^a	64.92 ^a	156.69 ^a	116.45 ^a	136.57 ^a	219.33 ^a	149.70 ^a	184.51 ^a
SE(±)	1.224	1.124	1.320	4.742	4.319	4.367	5.188	7.225	7.639	6.185	7.291	11.326

1. Week after sowing

2. Mean value of the means for the two years for 2010 and 2011 data

3. Mean in a column followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT

Table 3: Assessment of Crop Growth Rates (CGR) in Sunflower as influenced by Phosphorus levels in Southern Borno, Nigeria, during 2010-2011 rainy seasons and the two years means

P ₂ O ₅ (kg ha ⁻¹)	Crop growth rate(g dm ⁻² day ⁻¹)									
	6 WAS ¹			8 WAS			10 WAS			
	2010	2011	Mean ²	2010	2011	Mean	2010	2011	Mean	
0	4.69	2.63 ^{ab3}	3.66	6.07 ^{bc}	4.04	5.06 ^b	4.36 ^c	2.30	3.33	
20	4.73	2.32 ^b	3.53	5.71 ^c	4.73	5.22 ^b	4.36 ^c	2.21	3.28	
40	4.60	2.38 ^b	3.49	6.42 ^{bc}	4.35	5.39 ^{ab}	4.54 ^{bc}	2.50	3.52	
60	4.84	2.99 ^a	3.91	7.04 ^{ab}	4.04	5.54 ^{ab}	5.11 ^{ab}	2.49	3.80	
80	5.21	3.04 ^a	4.12	7.65 ^a	4.44	6.05 ^a	5.66 ^a	2.38	4.02	
SE(±)	0.316	0.285	0.386	0.501	0.282	0.478	0.323	0.250	0.465	

1. Week after sowing

2. Mean value of the means for the two years for 2010 and 2011 data

3. Mean in a column followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT

Table 4 shows that days to 50% flowering were not significant among P₂O₅ rates in 2010 rainy seasons; and results from 2011 and the two years means indicated that days to 50% flowering decreased statistically to 71.13 days in 2011 and 75.13 days in combined analysis at increasing P₂O₅ rates up to 60 Kg ha⁻¹ relative to higher values in the lower rates. Data on the effects of phosphorous rates on head dry weight of sunflower similarly indicated that increased P₂O₅ application up to 60 Kg ha⁻¹ statically increased results in 2011 rainy season and the two years mean (89.62g); as application of 80 Kg P₂O₅ ha⁻¹ in 2010 rainy season produced results which statistically out-weigh all other rates (Table 4). Results on 1000-grain weight shows that in 2011 rainy season, increasing P₂O₅ rates up to 80 Kg ha⁻¹ statically increased crop performance, relative to all other treatments. During 2010 and combined analysis however, the values for 1000-grain weight were statistically similar among all P₂O₅ rates except in the control experiment (0 Kg P₂O₅ ha⁻¹), which

when compared with 80 Kg P₂O₅ ha⁻¹ showed statistical significant difference (Table 4).

Table 5 shows that the effects of phosphorus rates significantly influenced grain and fodder yields in both years and their combined means. The application of 40 Kg P₂O₅ ha⁻¹ statistically increased grain yield performance in 2010 wet season (2405.90 Kg ha⁻¹); and in combined analysis, the above rate out-yielded all other rates (2114.60 Kg ha⁻¹) except at 60 Kg P₂O₅ ha⁻¹ (1992.30 Kg ha⁻¹). In 2011 rainy season, grain yield also increased statistically (1823.30 Kg ha⁻¹) as P₂O₅ rates increased to 40 Kg ha⁻¹ (Table 5). Similarly, data on fodder yield shows that application of 60 Kg P₂O₅ ha⁻¹ statistically recorded higher yield values in 2010 (3068.90 Kg ha⁻¹), 2011 (2023.40 Kg ha⁻¹) and in combined analysis (2546.20 Kg ha⁻¹). These results have statistical similarities with yield values recorded at 80 Kg P₂O₅ ha⁻¹ (Table 5).

Table 4: Assessment of Days to 50% flowering and 1000-grain weight in Sunflower as influenced by Phosphorus levels in Southern Borno, Nigeria, during 2010-2011 rainy seasons and the two years means

P ₂ O ₅ (kg ha ⁻¹)	Days to 50% flowering			Head dry weight (g)			1000-grain weight (g)		
	2010	2011	Mean ¹	2010	2011	Mean	2010	2011	Mean
0	78.13	83.07 ^{a2}	80.60 ^a	85.19 ^b	72.59 ^b	78.89 ^c	59.07 ^b	38.60 ^c	48.83 ^b
20	79.20	79.67 ^{ab}	79.43 ^a	86.99 ^b	73.20 ^b	80.09 ^{bc}	66.33 ^{ab}	37.67 ^c	52.00 ^{ab}
40	78.13	77.13 ^{ab}	77.63 ^{ab}	89.68 ^b	73.47 ^b	81.58 ^{bc}	65.20 ^{ab}	39.93 ^{bc}	52.57 ^{ab}
60	79.13	71.13 ^c	75.13 ^{bc}	87.61 ^b	91.63 ^a	89.62 ^{ab}	63.40 ^{ab}	44.40 ^b	53.90 ^{ab}
80	77.40	70.60 ^c	74.00 ^c	105.43 ^a	91.81 ^a	98.62 ^a	68.00 ^a	53.27 ^a	60.64 ^a
SE (+)	1.475	2.342	1.558	7.611	5.045	5.066	3.164	2.356	3.779

1. Mean value of the means for the two years for 2010 and 2011 data
2. Mean followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT

Table 5: Assessment of grain and fodder yield in Sunflower as influenced by Phosphorus levels in Southern Borno, Nigeria, during 2010-2011 rainy seasons and the two years means

P ₂ O ₅ (kg ha ⁻¹)	Grain yield (Kg ha ⁻¹)			Fodder yield (Kg ha ⁻¹)		
	2010	2011	Mean ¹	2010	2011	Mean
0	1462.6 ^{c2}	895.3 ^c	1178.9 ^d	2518.1 ^d	1602.0 ^b	2060.1 ^c
20	1860.9 ^{bc}	1310.2 ^b	1585.5 ^c	2697.2 ^{cd}	1641.9 ^b	2169.5 ^c
40	2405.9 ^a	1823.3 ^a	2114.6 ^a	2860.0 ^{bc}	1705.7 ^b	2282.8 ^{bc}
60	2161.2 ^b	1752.5 ^a	1992.3 ^{ab}	3068.9 ^{ab}	2023.4 ^a	2546.2 ^{ab}
80	2164.5 ^b	1668.7 ^a	1916.6 ^b	3275.0 ^a	2152.0 ^a	2713.5 ^a
SE (+)	207.20	107.14	154.57	167.54	75.66	189.33

1. Mean value of the means for the two years for 2010 and 2011 data
2. Mean followed by the same letter(s) are not significantly different at 5% level of probability according to DMRT

IV. DISCUSSION

Physiological growth parameters such as leaf area per plant, crop growth rates and dry matter production were not significantly influenced by phosphorus application during early growth phases at first sampling, and this is most presumably due to the fact that phosphate compounds was earlier held to soil colloids and lately released for plants uptake. This finding confirms earlier reports by [5], [7]. However, increase recorded in the above mentioned growth parameters during later growth periods were due to increased supply of phosphorus [8], which might have accelerated cell division and system development in plants as reported by [2].

Result from this study also indicated that increased phosphorus application reduced days to 50% flowering which conforms the findings of [6]), and this is due to role of phosphorus in plants flowering. Head dry weight however increased at increasing P₂O₅ rates due to obvious role of phosphorus in photosynthesis [1], which might have increased the production of assimilates which was

remobilized to the heads during reproductive phase. The above findings contradict earlier report from [13] whose result was not statistically influenced by phosphorus rates. Similarly, 1000-grain weight increased with increase P₂O₅ application and this could be ascribed to increased kernel development and grain filling efficiency as reported by [4]); and [6] which might have reduced the number of unfilled grains.

Grain yield increased due to increased phosphorus application, and this finding agrees with the reports of [9]); [11] and [10]). This is a clear indication that phosphorus is important in crop nutrition for grain formation, filling and ripening [3]. Photosynthesis positively influenced yield potentials, thus its quantum (photosynthesis efficiency) might have been peaked by the increase recorded in crop growth and leaf surface areas during growth phases as phosphorus rates increased; and this in turn increased the amount of assimilates later mobilized for grain yield. Furthermore, since phosphorus application have positive significant effects on stem and shoot dry matter, its increase might have influenced fodder

yield [12]. Besides, this increased the partitioning of materials for head development which incidentally becomes beneficial as haulm production increased fodder yield. Sunflower grain and fodder yields showed promising results from this study despite low rainfall, mid-rainy season drought that occurred and low inherent fertility of the soil in the study area. It could therefore be concluded that the crop confers higher potentials to substitute other indigenous oil and fodder crops in northern Nigeria.

REFERENCES

- [1] Rodriguez, D., Zubillaga, M.M. Ploschuk, E.L., Keltjens, W.G., Goudrian, J. and Lavado, R.S. (1998). Leaf area expansion and assimilate production in sunflower (*Helianthus annuus L.*) growing under low phosphorus conditions. *Plant Soil* 202: 133-147.
- [2] Muhammad, A.M., Malik, M.A. and Saleem, M.F. (2007). Impact of integration of crop manuring and nitrogen application on growth, yield and quality of spring planted sunflower (*Helianthus annuus L.*). *Pakistan Journal of Botany* 39(2): 441-449
- [3] Osman, E.B.A. and Awed. M.M.M. (2010). Response of sunflower (*Helianthus annuus L.*) to phosphorus and nitrogen fertilization under different plant spacings at New Valley. *Association of University Bulletin Environmental Research* 13(1) 11-18.
- [4] Karadogan, T., Akgun, I. and Altindal, N. (2009). Effects of leaf removal on sunflower yield and yield components and some quality characters. *Turkish Journal of Field Crops* 14(2): 45-54
- [5] Jalaluddin, M. and Maria, H. (2011). Effects of adding inorganic, organic and microbial fertilizers on seed germination and seedling growth of sunflower. *Pakistan Journal of Botany* 43(6): 2807-2809.
- [6] Hall, A.J., Connor, D.J. and Whitefield, D.M. (1989). Congregation of preanthesis assimilates to grain filling in irrigated and water stressed sunflower crops. *Field Crop Research* 20: 95-112.
- [7] Tilde, A.U. (1996). Effects of nitrogen and phosphorus rates on growth and yield of sunflower. Unpublished Ph.D. Agronomy Thesis, Ahmadu Bello University, Zaria.
- [8] Reddy, M.P., Mohammed, S. and Mohammed, S. A. (2000). Influence of nitrogen and phosphorus fertilizer on growth, yield components and yields of sunflower. *Crop Research* 20(2): 293-296.
- [9] Allam, S.M. (2000). Organic manuring and fertilizing for agriculture. Action plan for oil seed production. National Institute for Agriculture, Tanjodan
- [10] Awlakh, M.S. and Pasricha, N.S. (1996). Nitrogen and Phosphorus requirements and ability to scavenge soil nitrogen by hybrid sunflower. *Crop Improvement* 23(2): 247-252
- [11] Dhoble, M.V. (1998). Response of sunflower (*Helianthus annuus L.*) hybrids to nitrogen and phosphorus under rainfed conditions. *Indian Journal of Agronomy* 43(1): 138-141
- [12] Agrawal, M.M., Verma, B.S., Kumar, C. and Kumar, C. (2000). Effects of phosphorus and sulphur on yield, N, P and S contents and uptake by sunflower (*Helianthus annuus L.*) *Indian Journal of Agronomy* 45(1): 184-187
- [13] Ali, M., Khalil, S.K. and Nawab, K. (2000). Response of sunflower hybrids to various rates of nitrogen and phosphorus. *Sarhad Journal of Agriculture* 16(5): 477-483
- [14] Olowe, V.I.O., Adepimpe, O.A. and Obadijah, T.E. (2005). Response of sunflower (*Helianthus annuus L.*) to nitrogen and phosphorus application in the forest-savannah transition zone of south-west Nigeria. *Nigerian Journal of Horticultural Science* 10: 23-29.
- [15] Duncan, D. B. (1955). Multiple range and multiple "F"-tests. *Biometrics* II: 1-42

AUTHOR'S PROFILE



Nkeki Kamai

Date and Place of Birth: 15th March, 1960, Kuburbmbula

Permanent Home Address: C/o Ba Kamai Muta, Kuburbmbula Primary School, Chibok Local Government Area, Borno State, Nigeria.

Current Postal Address: Crop Production Department, Faculty of Agriculture, University of Maiduguri, PMB 1069, Maiduguri, Borno State.

Email: nkekikamai@yahoo.com, Phone No.: 08034618210

Educational institutions and qualifications with dates

University of Maiduguri, Maiduguri:	Ph.D Crop Production (Crop Physiology and Production)	2006-2010
University of Maiduguri, Maiduguri:	M.Sc. Crop Science (Crop Physiology and Production)	1991-1994
Ahmadu Bello University (A.B.U.), Zaria	B.Sc. (Agriculture)	1980-1984
School of Basic Studies, A.B.U., Zaria	Interim Joint Matriculation Examination Board (IJMB) Certificate	1979-1980
Government Community Secondary School, Biu:	West African Examination Council Certificate	1974-1979
Kautikari Primary School, Kautikari:	First School Leaving Certificate	1968-1974
Yashib Computer Training Institute, Maiduguri	Diploma in Computer Applications	2004
University of Maiduguri, Maiduguri:	Post Graduate Diploma in Education	2010-2012

Publications:

- Kamai, Nkeki (1989). Seeds in Agricultural Development. The Mobilizer. Borno Monthly Magazine. 4: 31.
- Kamai, Nkeki (1991). The Importance of Seed Dressing Chemical. The Mobilizer. Borno Monthly Magazine. 4: 18.
- Kamai, Nkeki (1992). Hybrid Maize Production. The Mobilizer. Borno Monthly Magazine. 6: 25.
- Kabura, B.H., Dada Y.M. and Kamai, N. (1999). Effects of mulching materials on irrigation water conservation and weed control on the yield of tomato (*Lycopersicon esculentum*, Mill) in semi arid region of Nigeria. *Journal of Arid Agriculture* 9: 17-20.
- Kamara, A.Y., Ellis-Jones, J. Amaza, P., Omigui, L.O., Helsen, J., Dugje, I.Y., Kamai, N., Menkir, A. and White, R.W. (2008). A participatory approach to increasing production of maize through *Striga hermonthica* control in Northeast Nigeria. *Expl. Agric.* 44: 349-363.
- Gwary, M.M., Kamai, N., Teli, I.A., Bassi, S.A., Msheli, J.M., Gaya, H.I.M. and Amaza, P.S. in consultation with Ellis-Jones, J. (2009). Involving farmers in research and extension. A guide for development workers based on PROSAB experience in Borno State, North East Nigeria. pp. 52.
- Sodangi, I.A. and Kamai, N. (2011). The global food crisis of 2006-2008: its causes and impact on Sub-Saharan Africa. *Maiduguri Journal of Arts and Social Sciences, MAJAS* 9: 1, 208-215.
- Garba, S. T., Santuraki, A. H., Barminas, J. T. and Kamai, N. (2012). Ethylenediaminetetraacetic acid (EDTA) Assisted Phytoextraction of the metals; Cu, Cd, Cr, Ni and Zn by crowfoot grass (*Dactyloctenium aegyptium*). *International Journal of Environmental Sciences* 1 (1): 1-10.