Ife Journal of Agriculture, 2020, Volume 32, Number 2

EFFECT OF INCORPORATED LEGUMES AND NPK FERTILIZER ON MAIZE (*ZEA MAYS* L.) NUTRIENT UPTAKE IN TUMU, GOMBE STATE

IBRAHIM A. K.[1], VONCIR N.[2]
[1]*Department of Soil Science, Federal University, Kashere, Gombe State*
[2] *Department of Soil Science, Abubakar Tafawa Balewa University, Bauchi*
ibrahima764@gmail.com, +2348035420025

ABSTRACT

A field experiment was conducted at the Teaching and Research farm of the Leventist Company, Tumu, Gombe State, Nigeria during the 2015 and 2016 wet seasons to investigate the effects of integrated application of green manure and mineral fertilizers. The experiment was laid out in randomized complete block design (RCBD) with three replications. The experimental area was 18 m x 45 m (810 m^2), the gross plot size was 5 m x 4 m (20 m^2), 1 m and 0.5 m was left between block and plots, respectively. The treatments comprised of Centrosema (T_1); Centrosema + N_{60} P_{30} K_{15} kg ha^{-1} (T_2); Lablab (T_3); Lablab + N_{60} P_{30} K_{15} kg ha^{-1} (T4); Mucuna (T_5); Mucuna + N_{60} P_{30} K_{15} kg ha^{-1} (T6); Sesbania (T_7); Sesbania + N_{60} P_{30} K_{15} kg ha^{-1} (T_8); recommended N_{120} P_{60} K_{30} kg ha^{-1} fertilizer (T_9) and Control (T_{10}). Maize (variety SYN 8 PVA) was used as test crop. The results revealed that the uptake of N, P and K by both stover and grain of maize were statistically significant ($p \leq 0.05$). The highest nutrient uptake was recorded from treatment T_4 (lablab + N_{60} P_{30} K_{15} kg ha$^{-1)}$ and the lowest value was obtained from the control. The overall result suggests that green manures in combination with N_{60} P_{30} K_{15} kg ha^{-1} inorganic fertilizer can be used as an alternative option to sole inorganic fertilization to achieve maximum values of nutrient uptake of maize. Integration of organic and inorganic fertilizers was better than using organic or inorganic fertilizer separately.

Keywords: Incorporation, Legume, inorganic, Green manure, Plant nutrient, Uptake,

INTRODUCTION

Maize (Zea mays L.) is a member of the grass family Poaceae (Toungos *et al.*, 2019*)*. Maize is a C_4 plant, short duration and quick growing crop. Maize is one of such staple foods and one of the main sources of calorie (Zamir *et al.*, 2013). However, it is regarded as the most important cereal in the world after wheat and rice with regard to area cultivated and total production (Oladejo and Adetunji, 2012). Globally, maize is the most widely cultivated cereal and it is grown in a range of agro-ecological environments, over an area of 159 million hectares with a worldwide production of 1.134 billion metrics tones in 2017. The largest producer, the United States topped the list of 6 maize producing countries which include China, Brazil, Argentina, Ukraine and India with an amount of about 366.6 million metric tons in 2018 (Shahbandeh, 2019). Nigeria leads African countries with nearly 11 million tones, on 6.5 million hectares of land with average yield of 1.6 tons per hectare and guinea savannah is the largest maize producing zone in Nigeria in 2018 (IITA, 2011; FAO, 2019).

The popularity of maize in Nigeria is partly due its high value as a food crop as well as fodder and source of fuel for rural communities. However, maize is used in many ways than any other cereal. It is used as human food, as a source of income, as fuel, feed for livestock and industrial purposes (Mosisa *et al*., 2002). In Nigeria maize yields remain low when compared to hectares of land under production with a decreasing trend over several years. For instance, in 2016, average maize yields were 1.75tha^{-1} as compared to 1.59tha^{-1} in 2017, which represents a 9.14% decrease in yield (Knoema, 2020). Studies conducted by Offiah (2015) shows that industries consumed over 60% of maize production and less than 40% to household consumption. Different factors are responsible for the low yield of the crop. Soil fertility and inappropriate crop nutrition management are some of the factors responsible for low yield of maize (Shah *et al*., 2009). In many parts of Africa including Nigeria, continuous cultivation of land with inappropriate farming methods is causing severe depletion of nutrients and soil organic matter, posing a serious threat to agricultural productivity and sustainability (Endris and Dawid, 2015). Loss of organic matter, macro and micronutrients' depletion, soil acidity, topsoil erosion and deterioration of physical soil properties are some of the primary causes of declining soil fertility (Zelleke *et al*., 2010). Initially, maize yields were increased by applying large amounts of inorganic fertilizers. However, this has led to soil problems such as soil degradation, declining crop yields, and global environmental issues. Thus, we need to develop and adopt environmentally friendly alternatives that can supplement or replace inorganic fertilizers. Organic fertilizers are environmentally sustainable and can maintain soil health when used in intensive maize cultivation. They help to conserve the amount and quality of organic matter in the soil, and supply N, P, K, and essential micronutrients (Timsina and Connor, 2001). Despite their huge potentials, using organic fertilizers alone is not efficient as they have a low nutrient content compared to inorganic fertilizers. Plants cultivated on organic fertilizer amended soil alone may suffer from nutrient deficiencies and produce low yields. However, the application of organic manure integrated with inorganic fertilizers helps neutralize soil pH, increased organic carbon levels and improved macro- and micronutrient availability, physical properties, and microbial activity (Liu *et al*., 2009), thereby increasing crop yields (Kumar *et al*., 2014). High yielding varieties have a high nutrient demand and are very responsive to fertilizer inputs. However, these varieties also mine the soil at higher rates than traditional varieties. Several studies confirmed that integrated application of organic and chemical fertilizer gave superior effect in terms of improved soil fertility and balanced plant nutrient (Ibrahim *et al*., 2018a; Ibrahim *et al*., 2018b; Ibrahim *et al*., 2017 and Shah *et al*., 2017). The objective of the study is to evaluate the effect of NPK, 20-10-10, green manure and their combinations on the nutrient uptake of maize.

MATERIALS AND METHODS

Experimental Site and Soil Characteristics:

The field experiment was conducted for two consecutive crop cycles (2015 and 2016) at the Research Farm of the Leventist Farm, Tumu (9º 55′ N and 10º 58′ E at an altitude of 325 m above sea level), in the Northern Guinea Savanna ecological zone of Nigeria with a mean annual temperature of about 31^0 C (minimum 26.9 ^{0}C and maximum 34 ^{0}C). The annual rainfall for the duration of the study was 369.4 and 2183.2 mm for 2015 and 2016, respectively (Ibrahim *et al.*, 2017). Soil analyses of the experimental field before planting in 2015 were determined by standard procedures as described by Page *et al.* (1982). The physico-chemical analyses of the soils are presented in Table 1. The chemical analysis of the incorporated green manure crops is presented in Table 2.

TABLE 1: SOIL PHYSICOCHEMICAL PROPERTIES BEFORE THE EXPERIMENT

Parameter Value	Parameter Value
Sand content	76.5%
Silt content	12.5%
Clay content	11.0%
Textural class	Sandy loam
pH($CaCl_2$)	5.0
Organic carbon (gkg^{-1})	5.4
Total nitrogen (gkg^{-1})	0.04
Available. P (mg/kg)	6.8
Ca^{2+} (cmol (+)/kg)	2.32
Mg^{2+} (cmol (+)/kg)	0.50
K^+ (cmol (+)/kg)	0.15

TABLE 2: CHEMICAL COMPOSITION OF THE GREEN MANURE CROPS USED IN THE EXPERIMENT

Parameter Value	N%	P%	K%	OC%	C : N
Centrosema	1.35	0.36	1.22	19.65	15.0
Lablab	3.29	0.51	1.29	34.15	11.0
Mucuna	2.41	0.43	0.96	27.45	11.0
Sesbania	3.35	0.41	1.31	33.10	10.0

Treatments and Experimental Design

The experimental area was 18 m x 45 m (810 m^2), the gross plot size was 5 m x 4 m (20 m^2) while 1 m and 0.5 m was left between block and plots, respectively. The net plot was 3 m x 3 m = 9 m^2. The experimental plots were in a Randomized Complete Block Design (RCBD) with three replications. The treatments consisted of *Centrosema* sole (T_1); Centro (*Centrosema*) + N_{60} P_{30} K_{15} kg ha^{-1} (T_2); Lablab sole (T_3); *Lablab* + N_{60} P_{30} K_{15} kg ha^{-1} (T_4); *Mucuna* sole (T_5); *Mucuna* + N_{60} P_{30} K_{15} kg ha^{-1} (T_6); *Sesbania* sole (T_7); *Sesbania* + N_{60} P_{30} K_{15} kg ha^{-1} (T_8); recommended N_{120} P_{60} K_{30} kg ha^{-1} fertilizer (T_9) and Control (T_{10}).

Sowing of green manure crops (Centro, *Lablab*, *Mucuna* and *Sesbania*) was done at two seeds per hole with spacing of 37.5 cm x 25 cm and incorporated into the soil at six weeks after sowing. A week after incorporation, the seeds of maize (variety SYN 8 PVA) were dressed with Apron Star 42 WS at the rate of 10 g sachet per 4 kg seeds for protection against soil and seed borne pests and diseases. NPK fertilizers (20-10-10) were applied two weeks after sowing (2WAS) at a rate of N_{120} P_{60} K_{30} kg ha^{-1} in plots treated with fertilizer only and N_{60} P_{30} K_{15} kg ha^{-1} in plots treated with green manure and fertilizer.

Data collection and analysis

Five tagged plants from each net plot i.e. the three inner rows of each plot were selected randomly for observations and record taking. Grain and stover samples were taken at the time of harvest. The samples were shade-dried and then transferred to oven and dried at 65 ^{0}C. The nutrient concentration and uptake were calculated on dry weight basis.

The nutrient uptake by grain and Stover were calculated by using the formula given below:

Nutrient uptake (kgha^{-1}) =

$$\frac{Nutrient\ content\ (\%)}{100} \times Dry\ weight\ \left(\frac{kg}{ha^{-1}}\right)$$

Data collected were subjected to analysis of variance (ANOVA) using SAS package version 9.0 software as described by SAS institute (2002). Differences between treatment means were separated by Duncan Multiple Range Test (DMRT) at 5% level of probability (Duncan, 1955).

RESULTS AND DISCUSSION

Chemical Composition of the green manure crops

The result of the green manure analysis shows a considerably higher nutrient status when compared to that of the field soil. According to Law-Ogbomo and Osaigbovo (2016), it is an indication of the green manure's capability of improving the soil nutrient status if allowed to mineralize for the release of its nutrients. The low C : N value indicates the ability of the green manure to enhance high decomposition and mineralization of nutrients in the incorporated legumes. This facilitated better uptake and accumulation of these nutrients for better maize growth and consequently, increased yield (Adesoji *et al.*, 2014).

Stover and grain Nitrogen uptake

N-uptake of maize stover and grain were affected by the residual content of green manure and inorganic fertilizer and these combinations are presented in Table 2. The nitrogen uptake, by maize, at harvest indicated wide variation amongst the treatments. The results showed that Lablab + N_{60} P_{30} K_{15} kg ha^{-1} recorded stover and grain N uptake of 64.3 and 76.6 kg ha^{-1}, which were significantly higher than all other treatments. Significantly lowest stover and grain nitrogen uptake of 24.3 and 13.2 kg ha^{-1} was recorded in control plot.

This results are consistent with the findings of (Ibrahim *et al*., 2017) who recorded significantly higher NPK uptake in millet amended with combined organic fertilizer with NPK fertilizer than those with organic or NPK fertilizer alone. The enhanced N uptake could be due to slow release of nutrients and improved synchrony between plant N demand and supply from the soil (Tilahun-Tadesse *et al*., 2013). Similar results were reported by Rao and Shaktwat (2002), Iqbal *et al*. (2008), Shah *et al*. (2017) and Ibrahim *et al*. (2018b). Lawan *et al.* (2010) reported that residual effect of organic fertilizers with inorganic fertilizers was significant on NPK uptake in yam compared to organic or NPK fertilizer alone in south-western Nigeria. Similar results were reported by Nyambati (2002) in the sub-humid highlands of north-western Kenya after incorporating Mucuna and Lablab residues. He attributed the enhanced N uptakes in green manure treated plots to N mineralization from the residues. Several studies by (Chang and Janzen, 1996; Paul and Clark, 1996; Muneshwar *et al*., 2001; Nevens and Reheul, 2003) have shown that organic materials (green manure, compost, farmyard manures) enhanced nutrient use efficiency by slow release of nutrients. However, addition of organic fertilizer increases nutrients mobilization and soil microbial activities; it also contributes in improving nutrition as well as crop root system. The present findings are in agreement with those of Ibrahim *et al.* (2017) who reported that increase in soil nitrogen level may affect positively N-uptake by maize stover.

TABLE 3: EFFECT OF TREATMENTS ON STOVER NITROGEN UPTAKE AND GRAIN NITROGEN UPTAKE OF MAIZE IN 2015 AND 2016.

	Stover Nitrogen uptake (kg ha^{-1})			Grain Nitrogen uptake (kg ha^{-1})		
Treatments	**2015**	**2016**	**Mean**	**2015**	**2016**	**Mean**
Centrosema + 0kg/ha NPK	17.4f	49.9d	33.6e	38.8f	31.9d	35.3d
Centrosema + N_{60} P_{30} K_{15} kg ha^{-1}	20.3d	76.3c	48.3c	48.1d	43.6c	45.8c
Lablab + 0kg/ha NPK	19.5d	75.1c	47.3c	49.1c	43.8c	46.4c
Lablab + N_{60} P_{30} K_{15} kg ha^{-1}	29.9a	98.7a	64.3a	73.8a	79.4a	76.6a
Mucuna + 0kg/ha NPK	18.0e	64.0d	41.1d	35.6g	28.6d	32.1d
Mucuna + N_{60} P_{30} K_{15} kg ha^{-1}	21.7c	75.0c	48.4c	63.2b	50.3b	56.8b
Sesbenia + 0kg/ha NPK	18.4e	62.9d	40.7d	25.4h	20.3e	22.8e
Sesbenia + N_{60} P_{30} K_{15} kg ha^{-1}	26.9b	90.7b	58.8b	41.2e	29.3d	35.3d
N_{120} P_{60} K_{30} kg/ha	22.8c	76.4c	49.6c	47.5d	35.3d	41.4c
Control	13.6g	34.9e	24.3f	15.2i	11.1f	13.2f
SE±	0.460	1.617	1.374	0.232	2.262	1.670
Significance	**	**	**	**	**	**

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT

Stover and grain phosphorus uptake

P-uptake of maize stover as affected by green manure and inorganic fertilizer are presented in Table 3. Results showed that application of Lablab + N_{60} P_{30} K_{15} kg ha^{-1} recorded stover and grain phosphorus uptake of 29.4 and 11.2 kg ha^{-1}, which was statistically higher than all other treatments tested. Significantly lowest stover and grain phosphorus uptake was observed in control plots during the period of investigation (10.2 and 2.1 kg ha^{-1}, respectively). The higher uptake obtained in this study might be attributed to better root establishment, translocation of absorbed nutrients from soil, transport of nutrients to seed and higher growth which led to better yields (Jaswinder *et al.* 2019). These findings are in line with the works of Bharud *et al.* (2014), Ibrahim *et al.* (2018b) and Kumar and Narayan (2018). Studies conducted by Sathish *et al.* (2011) showed that integrated application of organic and inorganic fertilizer significantly increased stover and grain P uptake, which is in conformity with the results obtained in this study. The control plots recorded significantly lower P uptake in comparison to all other treatments, justifying the need for incorporation of leguminous green manure and inorganic fertilizer. Similar results were reported by Jacqueline *et al.* (2008) and Moula (2005) who found that nutrient content as well as nutrient uptake by rice was highest due to combined application of organic and inorganic fertilizers. In this study, significant influence of green manure incorporation on stover and grain P uptake suggests improvements in the supply and availability of P for subsequent accumulation by maize (Adesoji *et al.*, 2015). This might be due to high microbial activity induced by the added organic residues which speed up P cycling (Melero *et al.*, 2007).

TABLE 4: EFFECTS OF TREATMENTS ON STOVER PHOSPHORUS UPTAKE AND GRAIN PHOSPHORUS UPTAKE OF MAIZE IN 2015 AND 2016.

	Stover phosphorus uptake (kg ha^{-1})			Grain phosphorus uptake (kg ha^{-1})		
Treatments	**2015**	**2016**	**Mean**	**2015**	**2016**	**Mean**
Centrosema + 0kg/ha NPK	8.1e	25.5c	16.8c	7.6f	4.2c	5.9d
Centrosema + N_{60} P_{30} K_{15} kg ha^{-1}	8.5e	32.8b	20.7b	13.1b	6.3b	9.7b
Lablab + 0kg/ha NPK	8.5e	34.6b	21.6b	8.1e	4.4c	6.2d
Lablab + N_{60} P_{30} K_{15} kg ha^{-1}	14.0a	44.7a	29.4a	13.8a	9.9a	11.9a
Mucuna + 0kg/ha NPK	7.5f	26.0c	16.8c	10.5c	4.5c	7.5c
Mucuna + N_{60} P_{30} K_{15} kg ha^{-1}	9.2d	35.0b	22.1b	13.1b	8.3a	10.8b
Sesbenia + 0kg/ha NPK	8.3e	26.1c	17.2c	9.0d	3.4c	6.2d
Sesbenia + N_{60} P_{30} K_{15} kg ha^{-1}	11.1b	33.2b	22.2b	9.0d	5.8b	7.4c
N_{120} P_{60} K_{30} kg/ha	10.4c	33.9b	22.2b	13.1b	5.8b	9.5b
Control	5.7g	14.6d	10.2d	3.0g	1.2d	2.1e
SE±	0.257	0.787	0.655	0.078	0.403	0.294
Significance	**	**	**	**	**	**

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT

Stover and grain potassium uptake

Data on Potassium uptake by maize grain affected by residual effect of green manure and inorganic fertilizer and these combinations are presented in Table 4. The potassium uptake indicated wide variation amongst treatments at maize harvest. The results deduce that treatment Lablab + N_{60} P_{30} K_{15} kg ha^{-1} recorded stover and grain N uptake of 47.5 and 9.9 kg ha^{-1}, which were significantly higher than all other treatments. Significantly lowest stover and grain nitrogen uptake of 12.2 and 1.6 kg ha^{-1} was recorded in control plots. Results obtained in this study are in line with the findings of Bhadoria and Prokash (2003) who reported that rice straw and grain K uptake increased significantly with combined application of organic manure and synthetic fertilizers. The positive and significant effect of green manure on stover and grain K-uptake is attributed to better supply of these nutrients from organic sources and to the proliferous root besides improvement in physical conditions (Jaswinder *et al.*, 2019). However, similar enhanced nutrient uptake has been reported in wheat (Sepat *et al*., 2010), winter maize (Mehta *et al*., 2011), sweet corn (Nandeha *et al*., 2016 and Rasool *et al*., 2016) and millet (Ibrahim *et al*., 2017). Similarly, Kachroo *et al.* (2006) and Davari *et al.* (2012) pointed out that the incorporation of rice residues increased productivity, yield components and nutrient uptake of wheat compared to no residue incorporation.

TABLE 5: EFFECT OF TREATMENTS ON STOVER POTASSIUM UPTAKE AND GRAIN POTASSIUM UPTAKE OF MAIZE IN 2015 AND 2016.

	Stover Potassium uptake ($kg\ ha^{-1}$)			Grain Potassium uptake ($kg\ ha^{-1}$)		
Treatments	**2015**	**2016**	**Mean**	**2015**	**2016**	**Mean**
Centrosema + 0kg/ha NPK	13.2d	40.6c	26.9b	6.5e	4.0b	5.2d
Centrosema + N_{60} P_{30} K_{15} kg ha^{-1}	14.2d	56.8b	35.5b	9.8d	7.0a	8.4b
Lablab + 0kg/ha NPK	14.0d	56.5b	35.4b	6.8e	3.5c	5.2d
Lablab + N_{60} P_{30} K_{15} kg ha^{-1}	24.6a	71.3a	48.0a	12.5a	7.3a	9.9a
Mucuna + 0kg/ha NPK	13.3c	42.2c	27.8b	5.7f	3.5c	4.5fe
Mucuna + N_{60} P_{30} K_{15} kg ha^{-1}	14.1d	56.4b	35.4b	11.8b	5.1a	8.5b
Sesbenia + 0kg/ha NPK	13.5d	42.1c	27.8b	5.2g	2.5c	3.8e
Sesbenia + N_{60} P_{30} K_{15} kg ha^{-1}	22.9b	47.1c	35.5b	10.5c	6.0a	8.3b
N_{120} P_{60} K_{30} kg/ha	16.3c	48.2c	32.3b	9.8d	4.2b	7.0c
Control	7.0e	17.3d	12.2d	2.0h	1.3d	1.6f
SE±	0.415	1.930	1.539	0.046	0.372	0.263
Significance	**	**	**	**	**	**

Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT

CONCLUSION

Residual effect of green manure combined with inorganic fertilizer increased N, P and K uptake in stover and grain of maize plant compared with control plots which showed lowest values of N, P and K uptake in stover and grain of maize plant. The integrated application of *Lablab* green manure and inorganic fertilizer at the ration of N_{60} P_{30} K_{15} kg ha^{-1} increased N, P and K uptake in stover and grain of maize plant for the two years of study when compared with single application of green manure or inorganic fertilizer. This experiment shows that integrated application of green manure and inorganic fertilizer was more effective in increasing nutrient availability than sole application of organic or inorganic fertilizer. However, green manure decomposition and consequent mineralization enhanced the accumulation of nutrients by the maize plant.

REFERENCES

Adesoji, A. G., Abubakar, I. U. and Labe, D. A (2014). Soil Chemical Properties as Affected by Incorporated Legumes and Nitrogen in Soil with Maize (*Zea mays* L.) in a Semi-Arid Environment. *International Journal of Agriculture Innovations and Research*, 3 (3): 2319-1473

Adesoji, A. G., Abubakar, I. U. and Labe, D.A (2015). Influence of Incorporated Legumes and Nitrogen Fertilization on Maize (*Zea mays* L.) Nutrient Uptake in a Semi-arid Environment. *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 8(3)II: 01 - 08

Bhadoria, P. B. S. and Prokash, Y. S. (2003). Relative influence of organic manures in combination with chemical fertilizer in improving rice productivity of lateritic soil. *Journal of Sustainable Agriculture*, 23(1) 77 - 87.

Bharud, S. R., Bharud, R. W. and Mokate, A. S. (2014). Yield and quality of sweet corn [*Zea mays* (L.) var. Saccharata] as influenced by planting geometry and fertilizer levels. *International Journal of Plant Sciences*, 9(1): 240 - 243.

Chang, C. and Janzen, H. H. 1(996). Long-term fate of nitrogen from annual feedlot manure application. *Journal of Environmental Quality*, 25: 785-790.

Davari, M. R., Sharma, S. N. and Mirzakhani, M. (2012). The Effect of combinations of organic materials and bio-fertilizers on productivity, grain quality, nutrient uptake and economics in organic farming of wheat. *Journal of Organic Systems*, 7: (2) 26 - 35.

Duncan, D.B. (1955). Multiple Ranges and Multiple F-tests. *Biometrics* 11: 1- 42.

Endris, S. and Dawid, J. (2015). Yield response of maize to integrated soil fertility management on acidic nitosol of Southwestern Ethiopia. *Journal of Agronomy*, 14(3), 152 – 157. doi:10.3923/ja.2015.152.157

FAO (2019). GIEWS - Global Information and Early Warning System: Country briefs, Nigeria. http://www.fao.org/giews/countrybrief/country.jsp?code=NGA, Accessed 24 Aug 2019.

Ibrahim, A. K., Voncir, N and Askira, M. S. (2017). Effect of incorporated legumes, NPK 20-10-10 and their combination on soil chemical properties of pearl millet grown soil (*Pennisetum Glaucum* (L.)). *Dutse Journal of Agriculture and Food Security (DUJAFS)*, 4 (1):126 – 135

Ibrahim, A. K, Ibrahim, S. A, Voncir, N and Hassan, A.M (2018a). Effects of Green manuring and Nitrogen Levels on the Yield and Yield Attributes of Maize (*Zea mays* L.). *Asian Journal of Soil Science and Plant Nutrition*, 2 (4): 1-11, 2017; Article no. AJSSPN.39905.

Ibrahim, A. K., Askira, M.S and Yakubu, H. (2018b). Effects of Incorporated Legumes, NPK 20-10-10 and their combination on Pearl Millet (*Pennisetum Glaucum,* B. R.) Nutrient Uptake in Northeastern Nigeria. *Journal of Agriculture, Food Security and Sustainable Environment*, 1(1): 79 - 86.

International Institute of Tropical Agriculture, IITA. (2011). Annual Report on Maize Production. Ibadan, Oyo State. Pp 97

Iqbal, T., Jilani, G., Chaudhry, A. N and Zahid, A. (2008). Studies on the residual effect of poultry litter application under wheat-maize cropping system. Presented an abstracted in *12th Congress of Soil Science Society of Pakistan* held on 20-23 October, 2008 at NWFP Agric. Univ. Peshawar. Jensen LS, Pedersen IS, Hansen TB, Nielsen NE. 2000: Turnover. Pp 230

Jacqueline, A., Prudente, A., Gilbert, C., Sigua, M., Manoch, K. and Alfredo, D. (2008). Improving yield and nutrient uptake potentials of *Japonica* and *Indica* rice varieties with nitrogen fertilization. *Journal of Agricultural Science*, 4(4): 427 - 434.

Jaswinder, K., Himani, K., Pankaj, S and Neeraj, J (2019). Effect of Plant Densities and Integrated Nutrient Management on Productivity, Nutrient Uptake and Quality of Sweet Corn (*Zea mays L. Saccharata*). IOSR *Journal of Agriculture and Veterinary Science* (IOSR-JAVS) 12.5: 38 - 42.

Kachroo, D., Dixit, A. K. and Bali, A. S. (2006). Influence of crop residue, fly ash and varying starter doses on growth, yield and soil characteristics in rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system under irrigated conditions of Jammu region. *Indian Journal of Agriculture Science*, 76 (1): 3 - 6.

Knoema, (2020). (Maize Yield) Production, Supply and Distribution of Agricultural Commodities by Market.

Kumar, A and Narayan, A. (2018). Influence of Planting Methods, Spacing and Fertilization on Yield and Quality of Sweet Corn (Zea mays L.). *International Journal of Current Microbiological Applied Science*, Special Issue-7: 1232 - 1237.

Kumar, P., Singh, F., Singh, A. P., Singh, M. (2014). Integrated nutrient management in rice-pea cropping system for sustainable productivity. *International Journal of Engineering Research Technique,* 3: 1093 – 1095.

Lawan, O. I., Adeoye, G. O., Asiedu, R. and Ojeniyi, S. O. (2010). *Effect of organo-mineral fertilizer on yield and nutrient uptake of white yam (Descorea rutundata prior) in southwestern Nigeria.* Emerging Challenges to Soil Resource in Times of Global Climate Change and Food Crises. In: Taiwo, L. B., Oluwatosin, G. A., Adediran, J. A., Are, K. S., Oke, A. O. and Ojiniyi, S. O (eds.). Proceedings of the 34th Annual Conference of the Soil Science Society of Nigeria, March 22-26th, 2010 held at institute of Agricultural Research and Training Moor Plantation, Ibadan, Nigeria 173-182.

Law-Ogbomo, K. E. and Osaigbovo, A. U. (2016). Growth and yield of ewedu (*Corchorus olitorius*) as influenced by food waste compost and inorganic fertilizer in a humid ultisol of south-western Nigeria. *Nigerian Journal of Agriculture, Food and Environment,* 12(1): 80 - 84.

Liu, M., Hu, F., Chen, X., Huang, Q., Jiao, J., Zhang, B., and Li, H. (2009). Organic amendments with reduced chemical fertilizer promote soil microbial development and nutrient availability in a subtropical paddy field: The influence of quantity, type and application time of organic amendments. *Applied Soil Ecology*, 42: 166 – 175.

Mehta, S., Bedi, S and Vashist, K. K. (2011). Performance of winter maize (Zea mays L.) hybrid to planting methods and nitrogen levels. *Indian Journal of Agricultural Sciences*, 81: 50 - 54.

Melero, S., Madejon, E. Ruiz, J. C. and Herencia, J. F. (2007). Chemical and biochemical properties of a clay soil under dry land agriculture system as affected by organic fertilization. *European Journal of Agronomy*, 26: 327 - 334.

Mosisa, W., Hadji, T., Mandefro, N., Aber a, D., Tanner, D.,Twumasi-Afriyie, S. (2002). *Maize production trends and research in Ethiopia: In* N. Mandefro, D. G. Tanner, & S. Twumasi-Afriyie Eds, 10 – 14. Retrieved from https://books.google.com.et/books?hl=en&lr=&id=gv11TqlUP 8C&oi=fnd&pg=PA10&dq=+Maize+production+trends+and+research+in+Ethiopia.+Mandefro,+N+Tanner,+DG,+TwumasiAfriyie,+S+(eds),+1014&ots=Rq5M6L3cLV&sig=T2l0LNbOwNJ_n5O73b_TnYa8Qzs&redir_esc=y#v=onepage&q&f=false

Moula, S. M. (2005). Comparative performance of rock phosphate and TSP on T. Aman rice in old

Brahmaputra Flood Plain and old Himalayan Piedmont plain soils. *MSc Thesis*, Department of Soil Science, Bangladesh Agricultural University, Mymensingh.

Muneshwar, S., Singh, V. P., Reddy, K. S and Singh, M. (2001). Effect of integrated use of fertilizer nitrogen and farmyard manure or green manure on transformation of N, K and S and productivity of rice-wheat system on a Vertisol. *Indian Journal Society of Soil Science*, 49: 430 - 435.

Nandeha, N., Dewangan, Y. K. and Sahu, P. (2016). Effect of crop geometry and nutrient management on yield performance of Sweet corn (Zea mays L. Saccharata) under Chhattisgarh plain ecosystem. *The Bioscan*, 11(4): 2293 - 2295.

Nevens, F. and Reheul, D. (2003). The application of vegetable, fruit and garden waste (VFG) compost in addition to cattle slurry in a silage maize monoculture: nitrogen availability and use. *European Journal of Agronomy*, 19: 189 - 203.

Nyambati, E. M. (2002). Management and nutritive evaluation of Mucuna pruriens and Lablab purpureus- based intercrops in the sub-humid highlands of north-western Kenya. *PhD thesis*, University of Florida, USA.

Offiah, E. O. (2015). Sustainability of Maize Based Production System in Anambra State Nigeria. Unpublished M.Sc. Thesis submitted to the Department of Agricultural Economics, University of Nigeria, Nsukka.

Oladejo, J.A. and Adetunji, M.O. (2012). Economic analysis of maize (Zea mays l.) production in Oyo state of Nigeria. *Agricultural Science Research Journals*, 2(2): 77 - 83, February 2012.

Page, A. L., Miller, R. H and Keeney, D. R. (1982). *Methods of Soil Analysis, Part-2.* 2nd Edn. *American Society of Agronomy*. Inc. Madison, Washington, USA. p. 98 - 765.

Paul, E. A and Clark, F. E. (1996). *Soil Microbiology and Biochemistry*. 2nd edition. San Diego, California; Academics Press, Pp 340.

Rao, S. S and Shaktawat, M. S. (2002). Residual effect of organic manure, phosphorus and gypsum application in preceding groundnut (*Arachis hypogea*) on soil fertility and productivity of Indian mustard (*Brassica juncea*). *Indian Journal of Agronomy*, 47: 487 - 494.

Rasool, S., Hamid, S., Kanth, R. H. and Khan, M. H. (2016). Effect of integrated nutrient management on quality, nutrient content and uptake of sweet corn (Zea mays L. Saccharata). *American Journal of Experimental Agriculture*, 13(6): 1-11.

SAS (2002). Statistical Analysis System (SAS) User's Guide (Version 9.0). (SAS Institute, Inc., North Carolina. USA).

Shah, S., Talat, H., Zamir, M., Shahid, I., Waseem, M., Ali, A., Bin, K. W. (2009). Growth and yield response of maize (Zea mays L.) to organic and inorganic sources of nitrogen. *Pakistan Journal of Life Society Science*, 7(2), 108 – 111.

Shah, S. A., Mohammad, W., Haroon, A and Khan, A (2017). Residual Effect of Poultry Manure and Mineral N Application on Maize Production under Wheat-Maize Cropping System. *Turkish Journal of Agriculture - Food Science and Technology*, 5(9): 1061-1065.

Shahbandeh, M (2019). Worldwide Production of Grain in 2018 – 2019 by type. Statista Factsheet. https://www.statistacom/statistics/263977/world-grain-production-by-type/ assessed on 23rd September 2019

Sathish, A., Govinda Gowda V., Chandrappa, H. and Nagaraja, K. (2011) Long term effect of integrated use of organic and inorganic fertilizers on productivity, soil fertility and uptake of nutrients in rice and maize cropping system, *International Journal of Scientific Nature*, 2(1) 84 – 88

Sepat, R. N., Rai, R. K and Dhar, S. (2010). Planting system and integrated nutrient for enhanced wheat (*Triticum aestivum*) productivity. *Indian Journal of Agronomy,* 55:114 - 118.

Toungos, M. D. (2019). Effect of Organic and Inorganic Fertilizers on Yield of Maize in Mubi North Local Government Area, Adamawa State, Nigeria. *International Journal of Innovative Agriculture and Biology Research,* 7(2): 26 - 35.

Tilahun-Tadesse, F., Nigussie-Dechassa, R., Wondimu, B and Setegn, G. (2013). Effect of Farmyard Manure and Inorganic Fertilizers on the Growth, Yield and Moisture Stress Tolerance of Rain-fed Lowland Rice. *American Journal of Research Communication*, 1 (4): 275 - 301.

Timsina, J. and Connor, D. J. (2001). Productivity and management of rice–wheat cropping systems: Issues and challenges. *Field Crop Research*, 69: 93 – 132.

Zamir, M. S. I., Yasin, G., Javeed, H. M. R., Ahmad, A. U. H., Tanveer, A., and Yaseen, M. (2013). Effect of different sowing techniques and mulches on the growth and yield behavior of spring planted maize (Zea mays L.). *Cercetari agronomice in Moldova*, 46(1), 7782.

Zelleke, G., Agegnehu, G., Abera, D and Rashid, S. (2010). Fertilizer and soil fertility potential in Ethiopia: Constraints and opportunities for enhancing the system. Washington, DC, USA: International Food Policy Research Institute (IFPRI). Zerihun. Pp 66