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CHANGES IN GROWTH AND YIELD ATTRIBUTES OF TWO SELECTED MAIZE VARIETIES AS INFLUENCED BY APPLICATION OF CHEMICAL (NPK) AND ORGANIC (BAT'S MANURE) FERTILIZERS IN PALA (CHAD) GROWN FIELD

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Abstract

The present experiment was conducted in Pala, region of the Mayo-Kebi West division, in a contribution to improve maize production in Chad. The work was oriented towards the evaluation of the interactions between chemical (NPK) and organic (bat's manure) fertilizers on growth and yield attributes of TZEE-W and IB selected maize varieties. The experimental design was a (5x2)x4 factorial design in which the main factor was the proportion of organic/chemical fertilizer (%), and the maize variety as the secondary factor, comprising the following six treatments repeated four times: control (T_0) with 0 % NPK and 0 % bat's manure; T_1 with 100% NPK; T_2 with 100% bat's manure; T_3 with 75% NPK and 25% bat's manure; T_4 with 75% bat's manure and 25% NPK; T_5 with 50% bat's manure and 50% NPK. Results show a variation in experimental soils pH of treatments from 5.91 to 7.92, depending on the proportion of the fertilizers applied. There were significant yield differences among treatments, as well as maize varieties. The 50% NPK+50% bat's manure was found as the best treatment to significantly ($p<0.0001$) enhance the yield of IB (51.2 t/ha) and TZEE–W (37.9 t/ha) maize varieties compared to their respective controls (7.25 t/ha and 6.76 t/ha). These results suggest that the combination at equal proportion of NPK and bat's manure could be recommended to sustainably improve maize production in Pala-Chad, thus with a considerable alleviation of the pollution risks that have been attributed to chemical fertilizer.

Key words: Bat's guano, Chad, Chemical fertilizer, Growth, Maize, Organic fertilizer, Yield.

Introduction

More than 800 millions people in the world are suffering from malnutrition among which are 200 millions children under 5 years old (Anon., 2004), some of whom are dying from infectious diseases related to this malnutrition (Pelletier *et al*., 1995). In Africa, 95 millions hectares of lands are threatened by irreversible degradation, if nutriments depletion continues to be severe. Despites the demographic growth explosion and increased in nutritional demand, Africa is the continent where hunger is currently in the habit of people, and where agricultural productivity is decreasing at a rate of 0.4% (Anon., 2009). Hence, local measures to circumvent hunger problems include water management, agro-syviculture and new strategies of pastures that cannot only sustain crop yields, but also, can improve soil fertility, while maintaining the diversity of cultures and reducing chemical fertilizer uses.

Agriculture is first within the primary sector and is considered as the pionier in the economy of Chad (Anon., 2005). After rice and barley, maize occupies the third rank worldwide in the cereal production (Memento Agronome, 2002). Grown for both as a fodder and grain crop (Khan *et al*., 2014), it is one of the most cultivated cereals in Subsaharan Africa with West and Central Africa accounting only for 5.2 million tons (De Groote, 2002). Considering its position in the world, and particularly in Africa, cultivation of maize in Chad needs to be encouraged, despites the growing constraints that empede its emergency. Among several constrainsts that include continuous cropping, increased population pressure on arable lands, degradation of land, low investment in soil fertility, inappropriate production technologies, bad weather and invasive weeds (Mwangi & Ely, 2001; Klan *et al*., 2014), those related to climate cannot be solved by local farmers; however, those related to soil fertility could be improved by providing soils with organic and chemical fertilizers. Soil organic fertilizer is an important source of nutrients for plant growth that needs to be maintained for agricultural sustainability (Herencia *et al*., 2007). Unlike chemical fertilizer which are not affordable to farmers due to its high cost, organic fertilizers such as bat's manure (guano) are available and may be associated to cereals, although not yet well known. Bat's manure is just the mixture of remains and excrements of bats that are harvested from caves. Rich in nitrogen and phosphorous, it provides important chemicals to crops. Bat's manure also has beneficial fungi and bacteria that act as a natural fungicide to protect plants from diseases (Kuepper, 2003). Averagely 60% of organic matter is used worldwide, but the proportion in use by stakeholfders in Chad is not significant (Olombo, 2000), despites the high agricultural activities (70-80%) conducted by Chadian growers.

Throughout the world, there are concerns over the increased use of fertilizers and pesticides in agriculture as they cause greater public health and environmental problems. Long term field experiments have clearly visualized the negative impact of continuous use of chemical fertilizers on soil health (Yadav, 2003). There is a need to adopt practices which can improve the soil health and increase the crop yield. Organic farming systems could be an option that ensures food, air, water, and soil quality, leaving the environment safe for the present and future generations.

Therefore, the main objective of the present study was to contribute in the alleviation of poverty and food insecurity by investigating on different NPK+ bat's manure combinations that could appropriately improve growth and yield of TZEE-W and IB selected maize varieties in Pala-Chad. The growth and yield attributes as affected by these fertilizers are further discussed.

Material and Methods

Description of the study site: Experiment was carried out in the CECADEC field in Pala-Chad, where the climate is of the sudanian type with 8 months of dry season extending from June to September (Anon., 2009). Rainfalls are not well distributed in time and space and is estimated at between 800-1200 mm/year (Anon., 2009). The maximum temperature is 45°C between February and April, while the minimum is 14°C between November and January. The main plant species found on site were *Daniellia olivieri, Parkia biglobosa*, and shrubs, the most common of which are *Balanites aegyptyca; Ziziphus mauritania, Detarium microcarpum, Burkea Africana.* The herbaceous species were *Imperata cyclindrica, Andropogan pseudapricu, Echnirochloa colona, Dactyloterium aegyptium, Paspalum virgatum* and *Panicum mascimum.* Three types of soil encountered in the region were: sandy-clay; clay and sandy soils (Anon., 2009).

Biological material, chemical and organic fertilizers: The chemical fertilizer NPK with the formula: 20-10-10 was bought in the market place of Pala, and contains 20% N, 10% P_2O_5; 10% K_2O, 5% **S**.

The organic fertilizer composed of bat's manure was also bought from a producer in Pala. The characteristics of the IB and TZEE-W maize varieties used in this study are summarized in Table 1.

Table 1. Agronomic characteristic of maize varieties.

Identification traits	**TZEE-W**	**IB**
Denomination	**Kamboinse early maturing (KEMY)**	**Kamboinse early maturing yellow (KEMY)**
Synonym	TZEE-W	IB
Country of origin	Burkina Faso	Burkina Faso
Mean height of plants (cm)	17-150	100-125
Number of leaves above the main cobs	5	5
Lenght of cobs (cm)	9.2	14.2
Section of cobs (cm)	3.6	4
Form of cobs	cylindro-conic	Cylindro-conic
Colour of seeds	White	Yellow
1000 seed weight at 15 % humidity (g)	182.79	225.6
Number of seed lines on the spike	12	15
Growing cycle at flowering (DAP)	45	55-60
Growing cycle at harvest (DAP)	85	105-115
Resistance to drought	acceptable	good
Potential yield on station (t/ha)	5	7
Source	IRAD/Garoua-Cameroon/2005	IRAD/Garoua-Cameroon/2005

DAP: Days after planting

Experimental design and treatments: The experiment was carried out in a (5x2) x 4 factorial design in which the main factor was the proportion of organic-chemical fertilizer (%), and the maize variety as the secondary factor. Each of the following six treatments was applied four times: control (T_0) with 0% NPK and 0% bat's manure; T_1 with 100% NPK; T_2 with 100% bat's manure; T_3 with 75% NPK and 25% bat's manure; T_4 with 75% bat's manure and 25% NPK; T_5 with 50% bat's manure and 50% NPK. The experimental soil (2360 m^2) was ploughed on flat at 15cm depth, with the help of animals. Plots were delimitated using fragments of small wood. An experimental unit was a 54m² plot, comprising 7 lines separated 0.8 m apart. Three seeds of each maize variety were sown in 22 holes per plot line with 0.4m spacing. Planting lines were oriented toward plot's slop to avoid leaching. 14 days after planting, plantlets were thinned to 2 per hole at the first weeding, as well as provision of the first fertilization to stimulate their growth. The second fertilization was applied at 30 DAP and the third at 45 DAP to stimulate flowering (Table 2).

Table 2. Quantity of fertilizers equivalent to different treatments.

Treatments	**NPK (Kg)**	**Bat's manure (Kg)**
T_0	0	0
T_1	1.35	0
T_2	0	1.35
T_3	1.01	0.34
T_4	0.33	1.02
T_5	0.66	0.66

Physico-chemical analysis of soil samples before fertilization: The analysis was carried out in the laboratory of soil water and plant of ITRAD, Chad. Soil pH was measured in a 1:1 soil-water ratio using a glass electrode (H19017 Microprocessor) of Cyberscan pH meter type. The water quality was assessed by measuring the conductivity in the production sites using an electronic conductivimeter Wagtech (USA), (Rhoades, 1982).

The ash content was determined using the method described by Anon., (1982). Hence, 5g of each sample was let to dry in a Naberthern type oven at 550ºC for 4 h, and weighed on an electronic balance. The ash content was determined by the formula:

$$TC= [(M_2-M_0)/ (M_1-M_0)] \times 100$$

where, Mo is the mass of the empty container; M_1 is the mass of the container with sample; M_2 is the mass of the container out of the oven.

The organic matter content was determined by the formula:

$$Mo = 100-Tc$$

where, Mo is the organic matter content; TC is the ash content.

The soil humidity was evaluated by Anon., (1982) method. Soil samples (2g each) were let to dry at 105 °C for 24 h. After cooling for 30 min, soil humidity was assessed as follows:

$$TH = [P_1-P_2/P_1] \times 100$$

where, $\mathbf{P_1}$ is the weight of sample before drying; $\mathbf{P_2}$ is the weight of sample after drying

Determination of soil texture and mineral nutrients: In order to characterize the soil of the experimental field, samples were taken across the field to a depth of 30 cm and bulked for laboratory analysis. In the laboratory, soil samples were air-dried, crushed using a wooden mortar and pestle and then sieved through a 2 mm mesh. The soil texture was determined by the Hydrometer method (Quansah, 2010). The granulometric analysis of soil was performed using a densimeter, calibrated at 20°C (Rodier *et al*., 2009). Organic matter was an important measurement because manure and mulches were incorporated into the soil. The organic matter was measured by the Walkey-Black method, for 0-15 cm depth for every plot (Walkey & Black, 1934). The total N was determined using the Kjeldahl method (Bremner, 1960). Phosphorus and potassium were determined as prescribed by (Rodier *et al*., 2009).

Assessment of growth and yield components: Plant height (from soil to the apex of the highest panicle), leaves length, stem diameter were determined from 20 randomly selected plants per experimental plot. For the computation of yield components, 20 plants were harvested per plot. One thousand seed weight was estimated by randomly taking 4×100 grains from each plot which were then weighed and the average value multiplied by ten. Seed yield/hectare was estimated from seed yield per experimental plot and extrapolated into yield/hectare.

Data analysis: Data were statistically analyzed by the analysis of variance (ANOVA) using a Statgraphic plus program (version 5.0). Means between treatments were segregated using the Least Significant Difference (LSD) procedure.

Results and Discussion

Soil physico-chemical analysis: The statistical analysis indicates that the soil composition is made up of sand (72.730 %) clay (22.925%) and limon (04.345 %). This sandly soil is thus pervious with a very low humidity. This finding is in agreement with results of Soltner (2003), who postulated that soil rich in sand or sieving soil is favorable to permeability, water retention, facilitates temperature exchanges, aeration and development of roots, but is sensible to erosion. Generally, soil conductivity before and after ploughing is low if there is a lack of mineral elements. Tayeb & Persoons (1996) indicated that soil and irrigated water salinity has an important effect on nitrification that is inhibited when soil electrical conductivity is 2.5m/s, whereas ammonification is reduced by 50%. The soil pH varied from 5.59 to 7.97, within the range of 5.5 to 9.5 pH values reported by Strullu & Planchette (1991), in other soils, which is the pH interval tolerated by some mycorrhizal strains associated to maize (Kouayanl, 2010). The increase in pH in amended treatments was postulated to be due to the suppression of the activity of Fe and Al oxides and hydroxides, which play a vital role in protonization-deprotonization mechanism, controlling H+ ion concentration in soil solution (Choudhary & Kumar, 2013) (Table 3).

The soil nitrogen, phosphorus and potassium contents were very low and estimated at 0.069, 0.201 and 0.406 mg/g of soil respectively. These elemental nutrients have been reported to be influenced by soil temperature and humidity (Misra & Tyler, 1999).

The soil organic matter was 0.085%, attesting the low soil humidity and confirming the findings of Hood (2001), who revealed that humidity is influenced by organic matter that increases the soil water retention capacity.

Influence of different fertilizers on maize growth parameters: Growth behavior of the crop plant is reflected by the final height of the plants at maturity. Combined NPK and organic fertilizer (bat's manure) promoted plant growth (height, leave length, stem diameter) in comparison to control plots. In general, the TZEE-W plants were taller than those of IB maize plants, the best plant height being achieved by treatment T5 for TZEE-W (2.05 m) and IB (1.76 m) maize varieties (Fig. 1). As far as this parameter is concerned, the negative control significantly $p<0.0001$) showed the lowest performance compared to all the other treatment for the two maize varieties. Our results fail within the maize height range of between 0.6-6 m previously reported (Soltner, 2003), but are closer to between 1.74 - 2.01m revealed in maize amended with various animal manures in India (Choudhary & Kumar, 2013).

Table 3. Physico-chemical components of soil.

Treatments	Conductivity (mS/m)	Humidity (%)	pH, H2O
T_0	32.5c	1b	6.30c
T_1	253f	0a	5.92a
T_2	69.33d	1b	7.84d
T_3	30.89b	1.3b	6.36c
T_4	24.76a [a]	3c	7.96e
T_5	148.73e	3c	6.06b
p-value	6.12	0.01	0.14
LSD at 10^{-4}	< 0.0001	< 0.0001	< 0.0001

T0: 0g bat's manure + 0g NPK; T1: 100% NPK (6.11 g/plant); T2: 100% bat's manure (6.11g g/plant); T3: 75% NPK (4.59 g/plant) +25% bat's manure (2.7 g/plant); T4: 75% bat's manure (4.59 g/plant) +25% NPK (2.7 g/plant); T5. 50% NPK (3.24 g/plant) + 50% bat's manure (3.24 g/plant)

Results in table 4 reveal that the maize leaves length of IB and TZEE-W maize varieties increase with time from 15 DAP to maturity. At 15 DAP differences were already noticed between treatments, with the leave length of treatments T4 for IB variety (p = 0.038), T3, T4, T5 for TZEE-W variety (p<0.0001) significantly dominating the other treatments. Then treatment T5 started to take over the domination from flowering to maturity, giving the best leave growth with 1.18 m for IB and TZEE-W maize varieties. This leave length was above the mean range of 35-45 cm reported by Anon., (1981).

As far as the stem diameter is concerned, treatment T5 started to significantly (p<0.0001) enhance this parameter at 15 DAP, and continue throughout the growing cycle up to maturity. However, treatments T3, T4 and T5 did not show differences in the enhancement of this parameter for which averagely 8 cm was the highest stem diameter at maturity for both maize varieties.

Integrated use of organic and chemical fertilizer plays greater role in the improvement of growth and development of plants. Higher growth rate was found in NPK or bat's manure amended plots due to the more availability of plant nutrients, enzymes, vitamins and better soil characters which helped the plant to uptake more soil nutrients along with water (Satyanarayana *et al*., 2002; Ayoola & Makinde, 2008). Organic manure, especially bat's manure supplies balanced nutrients to plant roots and stimulates growth, increases organic matter content of the soil including the 'humic substances' that affect nutrient accumulation and promote root growth (Canellas *et al*., 2000). These results are supported by those of Shah *et al*., (2009), Achieng *et al.*, (2010), who reported that plant height, number of grains per cob, 1000-grain weight, grain yield and harvest index of maize gave higher values, when N and farmyard manures were integrated as compared to the alone application of the two sources of nutrients. Similar results were revealed by Elamin & Elagib (2001), who reported significant differences between non-treated and treated maize plants with organic and inorganic fertilizers.

Date of 50% flowering: The date at 50% flowering indicates the period at which half of the plant in a plot has flowered. Data in figure 2 indicate that for both maize varieties, treatments T_2, T_4, T_0 flowered earlier (between 43 and 47 DAP) than treatments T_1 and T_5 (between 47 and 56 DAP). The negative control (T0) being always the first to set flowers. The date of 50% flowering was also reported at between 47 and 54 DAP in maize under different animal wastes amendment (Choudhary & Kumar, 2013).

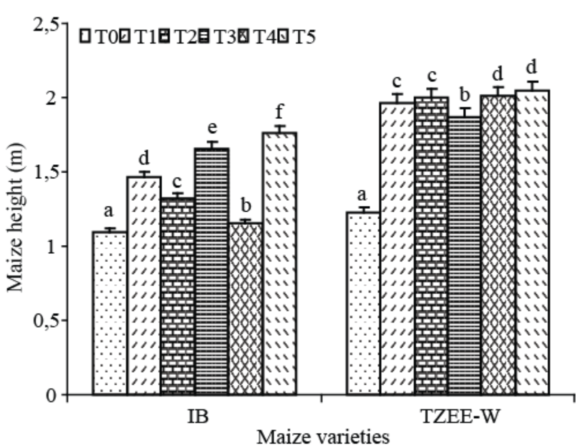

Fig. 1. Changes in maize height as influenced by fertilizer combinations.
T0: 0g bat's manure + 0g NPK; T1: 100% NPK (6.11 g/plant); T2: 100% bat's manure (6.11g g/plant); T3: 75% NPK (4.59 g/plant) +25% bat's manure (2.7 g/plant); T4: 75% bat's manure (4.59 g/plant) +25% NPK (2.7 g/plant); T5. 50% NPK (3.24 g/plant) + 50% bat's manure (3.24 g/plant)

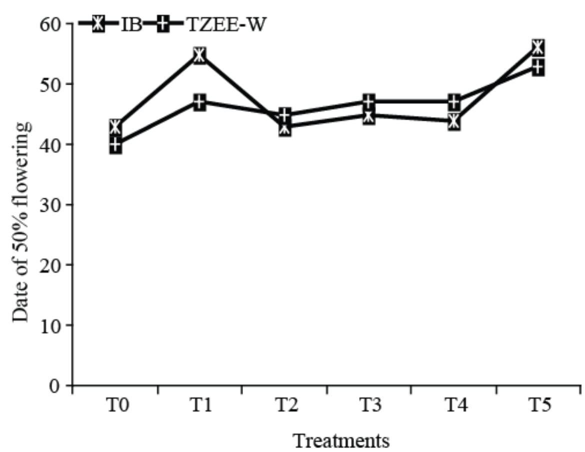

Fig. 2. Variation of 50% flowering dates of IB and TZEE-W maize varieties as affected by fertilizer combinations
T0: 0g bat's manure + 0g NPK; T1: 100% NPK (6.11 g/plant); T2: 100% bat's manure (6.11g g/plant); T3: 75% NPK (4.59 g/plant) +25% bat's manure (2.7 g/plant); T4: 75% bat's manure (4.59 g/plant) +25% NPK (2.7 g/plant); T5. 50% NPK (3.24 g/plant) + 50% bat's manure (3.24 g/plant)

Table 4. Influence of fertilizer combinations on leave length and stem diameter of maize varieties at various growth periods.

Treatments	Maize varieties and growth parameters					
	IB			TZEE-W		
	Leave length (m) at					
	15 DAP	flowering	maturity	15 DAP	flowering	maturity
T0	0.33a	0.43a	0.44a	0.42a	0.56a	0.67a
T1	0.33a	0.78e	1.13c	0.42a	0.98c	1.14b
T2	0.34ab	0.53b	1.09b	0.41a	0.82b	1.15b
T3	0.33a	0.46a	1.08b	0.61c	1.05cd	1.22b
T4	0.36b	0.67c	1.13c	0.64c	1.03c	1.12b
T5	0.35ab[b]	0.73d	1.18d	0.54b	1.15d	1.19b
p-value	= 0.038	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
LSD at 10^{-4}	0.353	0.053	0.04	0.07	0.126	0.45
	Stem diameter (cm) at					
T0	4.16c	5.07a	6.09a	4.1c	5.03a	6.16a
T1	3.53a	6.13b	7.23b	4.05c	6.2b	7.53b
T2	4.06c	5.9b	7.59c	3.46b	7.1c	8.03c
T3	4.16c	7.1d	8.0d	4.06c[c]	7.03c	7.53b
T4	3.76b	6.83c	8.1d	3.23a	6.53b	8.3d
T5	4.14c	7.07cd	8.03d	4.5d	7.06c	8.4d
p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
LSD at 10^{-4}	0.233	0.226	0.363	0.230	0.330	0.266

T0: 0g bat's manure + 0g NPK; T1: 100% NPK (6.11 g/plant); T2: 100% bat's manure (6.11g g/plant); T3: 75% NPK (4.59 g/plant) +25% bat's manure (2.7 g/plant); T4: 75% bat's manure (4.59 g/plant) +25% NPK (2.7 g/plant); T5. 50% NPK (3.24 g/plant) + 50% bat's manure (3.24 g/plant)

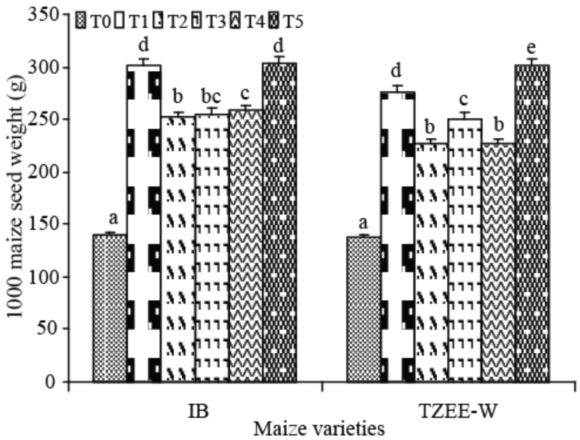

Fig. 3. Variation of 1000-seed weight in different varieties and treatments
T0: 0g bat's manure + 0g NPK; T1: 100% NPK (6.11 g/plant); T2: 100% bat's manure (6.11g g/plant); T3: 75% NPK (4.59 g/plant) +25% bat's manure (2.7 g/plant); T4: 75% bat's manure (4.59 g/plant) +25% NPK (2.7 g/plant); T5. 50% NPK (3.24 g/plant) + 50% bat's manure (3.24 g/plant)

Changes in the 1000 seed weight of IB and TZEE-W maize varieties as influenced by fertilizer combinations: The 1000-seed weight varied with maize varieties and treatments from 140 and 138g for the negative control to 304 and 301 g for treatment T5 (50% NPK+50% bat's manure), respectively in IB and TZEE-W maize varieties. These 1000 seed weight values were greater than 124-161g/treatment recently reported for organic-inorganic amended maize under Mediterranean climatic conditions (Efthimiadou *et al*., 2010). For the same maize variety, there was a significant difference (p<0.0001) between treatments (Fig. 3), with the higher 1000 seed weight attributed to treatment T5 (50% bat's manure and 50% NPK). The 1000-seed weights of all (NPK +bat's manure) combinations were greater than that of the negative control (T0) for each of the two varieties. For each treatment, the 1000-seed weight of IB maize variety was significantly (p=0.021) greater than that of TZEE-W variety.

Seed yield of the two maize varieties as affected by fertilizer combinations: A partial view of bat's manure field and their derived cobs at harvest is given in figure 4 that indicates their phenotipic variations. For each of the two maize varieties treatment T5 (50% NPK+50% bat's manure) significantly (p<0.0001) provided the best yield (IB = 51.7 t/ha; TEEZ-W = 37.56 t/ha) as compared to yields of other treatments (Fig. 5). Throughout, treatment T0 (no bat's manure + no NPK) yielded the lowest seeds for each maize variety. These results are greater than those of Anon., (2008), who obtained 20-50 t/ha for local and improved maize varieties, and suggest that the fertilization of the two maize varieties with 50% NPK+50% bat's manure is the best combination treatment for high yield, confirming results of the aforementioned growth parameters. Maize yield was thus influenced by NPK and bat's manure combination. Addition of organic matter for soil improvement of maize yield is well known (Bahrani *et al*., 2007; Rasool *et al.*, 2008; Efthimiadou *et al*., 2010). Our results are in agreement with findings of Mohsin *et al*., (2012), Choudhary & Kumar (2013) who postulated that amending plant respectively with "Guanotsar" associated to chemical fertilizer or nitrogen throughout different combinations of urea and farmyard were the best yielding associations for improved maize production.

Fig. 4. A partial view of bat's guano plots for TZEE-W (A) and IB (B) maize varieties and their repective cobs (C) and (D) after harvest.

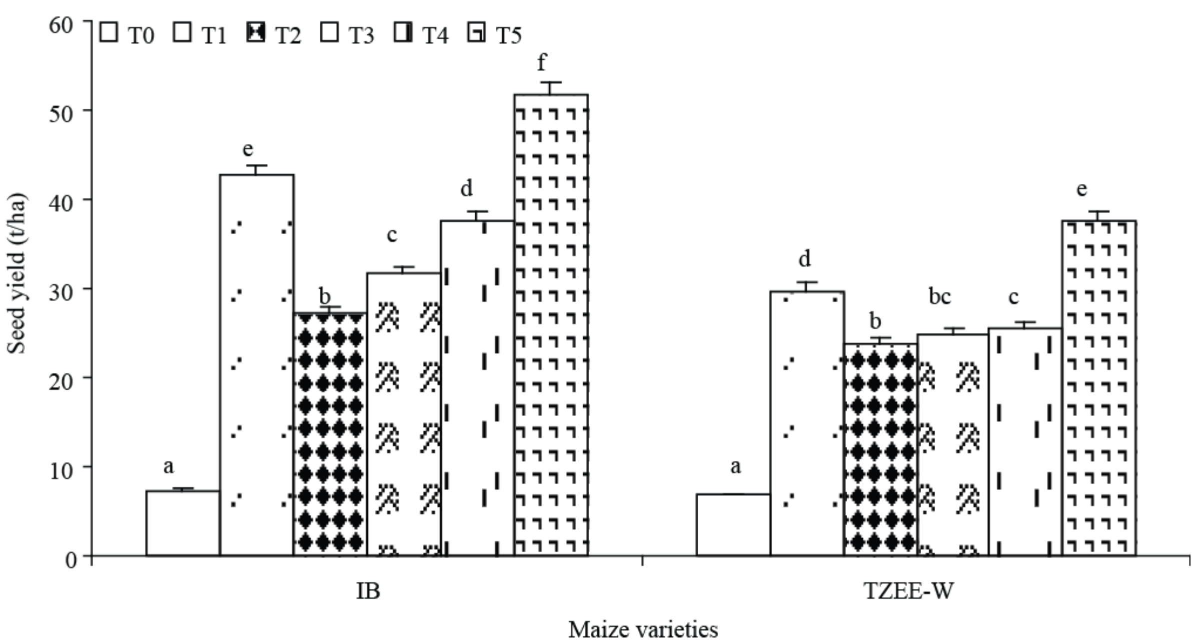

Fig. 5. Seed yield of the two maize varieties (t/ha) as influence d by treatments.
T0: 0g bat's manure + 0g NPK; T1: 100% NPK (6.11 g/plant); T2: 100% bat's manure (6.11g g/plant); T3: 75% NPK (4.59 g/plant) +25% bat's manure (2.7 g/plant); T4: 75% bat's manure (4.59 g/plant) +25% NPK (2.7 g/plant); T5. 50% NPK (3.24 g/plant) + 50% bat's manure (3.24 g/plant)

Conclusion

We have been able to establish that the combination of 50% NPK amended with 50% bat's manure is the best treatment indicated to get maximum IB and TZEE-W maize yield per hectare under agro-ecological conditions of Pala in Chad. This combination could be recommended to substitute the 100% chemical fertilizer NPK treatment. Further research will be investigated to determine the chemical composition of bat's manure, and extend the utilization of 50% bat's manure + 50% NPK combination treatment on other common appreciated cereals such as sorghum and millet in the region.

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References

Achieng, J.O., G. Ouma, G. Odhiambo and F. Muyekho. 2010. Effect of farmyard manure and inorganic fertilizers on maize production on Alfisols and Ultisols in Kakamega, western Kenya. Agric. *Biol. J. N. Am*., 1(4): 430-439.

Anonymous. 1981. Larousse Bookshop, pp. 707-713.

Anonymous. 1982. French Association of Normalization. Collection of French Norms of products derived from fruits and legumes. Fruit Juces. 1^{rt} edition. Paris, France, 327p.

Anonymous. 2004. Food and Agricultural Organisation of the United Nations. International year of rice. http// www. Fao. Org/rice 2004.

Anonymous. 2005. Secondary Moral and Civic Education. School and Scociety, Aubain Graphics, 179p.

Anonymous. 2008. Growth of maize in East Africa. Practical collection guide, CTA.

Anonymous. 2009. Annual Report, pp. 6-17.

Anonymous. 2009. Economic progress enhances development possibilities for Africa, but soil degradation remain a major problem. Section of Division Earth Warning and Assessment (DEWA). United Nations Environment Program (UNEP). 4p.

Ayoola, O.T. and E.A. Makinde. 2008. Performance of green maize and soil nutrient changes with fortified cow dung. *African J. Plant Sci*., 2 (3): 19-22.

Bahrani, M.J., M.H. Raufat and H. Ghadiri. 2007. Influence of wheat residue management on irrigated corn grain production in a reduced tillage system. *Soil Tillage Res*., 94: 305-309.

Bremner, J.M. 1960. Determination of nitrogen in soil by Kjedahl method. *J. Agric. Sci*., 55: 11-33.

Canellas, L.P., F.L. Olivares, A.L. Okorokova and R.A. Facanha. 2000. Humic acids isolated from earthworm compost enhance root elongation, lateral root emergence and plasma membrane H+-ATPase activity in maize roots. *Inter. J. Plant Physiol*., 130: 1951-1957.

Choudhary, V.K. and P.S. Kumar. 2013. Maize production, economics and soil productivity under different organic source of nutrients in eastern himalayan region. *India. Int. J. Plant Prod.*, 7(2): 167-186.

De Groote, H. 2002. Maize yield losses from stemborers in Kenya. *Insect Sci. Appl*., 22(2): 89-96.

Efthimiadou, A., D. Bilalis, A. Karkanis and B. Froud-Williams. 2010. Combined organic/ inorganic fertilization enhance soil quality and increased yield, photosynthesis and sustainability of sweet maize crop. *Austr. J. Crop Sci*., 4(9): 722-729.

Elamin, A.E. and M.A. Elagib. 2001. Comparative study of organic and inorganic fertilizers on forage corn (*Zea mays* L.) grown on two soil types. *Qatar Univ. Sci. J*., 21: 47-54.

Herencia, J.F., J.C. Ruiz-Porras, S. Melero, P.A. Garcia-Galavis, E. Morillo and C. Maqueda. 2007. Comparison between organic and mineral fertilization for soil fertility levels, crop macronutient concentrations and yield. *Agron. J*., 99: 973-983.

Hood R.C. 2001. The Effect of Soil Temperature and Moisture on Organic Matter Decomposition and Plant Growth. *Isotopes in Environmental and Health Studies*, 37(1): 24-41.

Khan, H., K.B. Marwat, M.A. Khan and S. Hashim. 2014. Herbicidal control of parthenium weed in maize. *Pak. J. Bot*., 46(2): 497-504.

Kouayanl, P. 2010. Influence of mycorrhizal inoculation on rice yield in a small irrigated area in Ambedane (Douguia). *Post-graduate dissertation*, High School of Agricultural and Forestry Science and Technology, Chad, 33p.

Kuepper, G. 2003. Manures for Organic Crop Production. Soil System Guide. Appropriate Technology Transfer for Rural Areas (ATTRA), 12p.

Memento Agronome. 2002. CIRAD-GRET, pp. 785-792.

Misra, A. and G. Tyler. 1999. Influence of Soil Moisture on Soil Solution Chemistry and concentrations of Minerals in the Calcicoles *Phleum phleoides* and *Veronica spicata* Grown on a Limestone Soil. *Ann. Bot.*, 84: 401-410.

Mohsin, A.U., J. Ahmad, A.U.H. Ahmad, R.M. Ikram and K. Mubeen. 2012. Effect of nitrogen application throughout different combinations of urea and farm yard manure on the performance of spring maize (*Zea mays* L.). *J. Anim. Plant Sci*., 22(1): 195-198.

Mwangi, P.N. and A. Ely. 2001. Assessing risks and benefits: Bt maize in Kenya. *Biotech. Dev. Monitor*, 48: 5-9.

Olombo, J.R. 2000. Fertilization. Global Report, CTA, Bruxelle, pp. 105- 117.

Pelletier, D.L., E.A.J. Frongillo, D. Schroeder and J.P. Habicht. 1995. The effects of malnutrition on child mortality in developing countries. *Bull. World Health Org*., 73 (4): 443-448.

Quansah, W.G. 2010. Effect of organic and inorganic fertilizers and their combinations on the growth and yield of maize in the semi-deciduous forest zone of Ghana. *Master thesis*. Department of soil and crop Science, University Kwame Nkrumah of Science and Technology, Kumasi, Ghana, 148p.

Rasool, R., S.S. Kukal and G.S. Hira. 2008. Soil organic carbon and physical properties as affected by long-term application of FYM and inorganic fertilizers in maize-wheat system. *Soil Tillage Res*., 101: 31-36.

Rhoades, J.D. 1982. Soluble Salts, *Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties*. American Society of Agronomy Monograph. 2nd edition, USA.

Rodier, J., B. Legure and N. Merlet. 2009. *Water Analysis*. 9th edition, Dunod, Paris, France, 1529p.

Satyanarayana, V., P.V. Vara Prasad, V.R.K. Murthy and K.J. Boote. 2002. Influence of integrated use of farmyard manure and inorganic fertilizers on yield and yield components of irrigated lowland rice. *J. Plant Nutr*., 25: 2081-2090.

Shah, S. T. H., M.S.I., Zamir, M. Waseem, A. Ali, M. Tahir and W. B. Khalid. 2009. Growth and yield response of maize (*Zea mays* L.) to organic and inorganic sources of nitrogen. *Pak. J. Life Soc. Sci*., 7(2): 108-111.

Soltner, D. 2003. The basis of plant production. Tome I: Soil and its improvement 23rd edition, pp. 97- 327.

Strullu, D.G. and C. Planchette. 1991. Mycorrhiza in horticulture. *PHM Review Horticole*, 352: 50-55.

Tayeb, A.H. and E. Persoons. 1996. Modern Agriculture, Collective Book, Hatier-AUPELF-UREF, 544 p.

Walkey, A. and I.A. Black. 1934. An examination of the methods for determining soil organic and proposed modification of chromic acid titration method. *Soil Sci.,* 37: 29-38.

Yadav, J.S.P. 2003. Managing soil health for sustained high productivity. *J. Indian Soc. Soil Sci,*. 51 (4): 448-465.

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