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Influence of Organic Manure (FYM) and Inorganic Fertilizer (N PK) on Nutrient Uptake, Growth and Yield of Sorghum in Maiduguri.

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Abstract: *The experiment was conducted in the Research and Demonstration Farm of Lake Chad Research Institute, in Maiduguri (semi-arid region). The experiment consists of nine fertilizer treatments which include both organic and inorganic sources and was accomplished using A 3 x 3 factorial experiment was laid out, comprising one sorghum variety (ICSV III), tested under three levels of FYM (0, 5.0 and 7.5 t/ha) and three levels of NPK (0, half and full dose of the recommended rates). The experiment was laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The revealed that Plant height at three growth periods was significantly higher under 7.5t FYM + $N_{64}P_{32}K_{30}$ than under all other treatments. Similarly, the grain yield and panicle weight in the different fertilizer treatments ranged from 180.8 to 2051.6 kg/ha and 372.5 to 3106.9 kg/ha, respectively. The highest values of both parameters was obtained in treatment with the application of 7.5t FYM + $N_{32}P_{16}K_{15}$ kg/ha. Straw weight and total dry matter ranged from 2398.6 to 5740.6 kg/ha and 2771.1 to 8847.5 kg/ha, respectively, of all the treatments, the one with application of 7.5t FYM + $N_{64}P_{32}K_{30}$ had significantly higher values than the other treatments. Plant analysis for N P and K as well as uptake in leaf, straw and grain indicate that application of 7.5t FYM + $N_{32}P_{16}K_{15}$ kg/ha gave the best result. Therefore, the application of 7.5t FYM + N32P16K15 kg/ha is, therefore, recommended for sorghum production in the study area.*

Keywords: *Sorghum; Organic; Inorganic and Fertilizer.*

1.0 INTRODUCTION

Sorghum (*Sorghum bicolor L.*) occupies about 45 - 50% of the total land area under cultivation in Nigeria, mostly in the savanna zone where it constitutes the major food grain sources. The production of sorghum in Nigeria has been estimated to be about 8.824 million tonne of grain sorghum (CBN, 2000). In the last few years' local farmer in the savanna region of Nigeria, where bulk of the crop is grown, perceived a steady decline in the productivity of this crop mainly due to soil and climatic constraints (Rayar, 1988). This crop is continuously produced with little or no nutrient replacement through chemical or organic fertilizer (Smaling *et al.,* 1997). Many interrelated factors which are both natural and managerial, cause soil fertility decline as characterized by decline in per capita food availability among smallholder farms in Africa. An estimated rate of 130 – 150 kg per person over the

past 35 years of production has been reported (Bationo, 2003). This downward trend is attributed to insufficient nutrient inputs relative to exports, primarily through harvested products, leaching and gaseous as well as erosion losses (Smaling *et al.*, 1997). Although the use of organic manure has been an age-long practice in crop production, it is now receiving renewed attention worldwide. This renewed attention has been encouraged by the recent clamor for improvement in the organic matter contents of agricultural soil as sink for CO_2 and the high demand for organic foods (Agboola and Fagbenro, 1985). The use of chemical fertilizer and recycling of nutrient in crop residues are the obvious source to arrest the nutrient depletion in soils (Rayar, 2000; Brady and Weil, 2002). Innovative combination of organic and inorganic nutrient sources must be used to increase nutrient input and to recycle the nutrients once they are incorporated. Synergistic effects have been achieved when organic and inorganic fertilizers are applied in combined form, it initiates better yield increase more than when they are applied separately (ICRISAT, 1997). The combination can be used to increase yields and simultaneously maintain and improve soil quality as reported by Kwari *et al.* (1998). Maiduguri zone is an area embattled by low organic matter contents and facing inadequate supply of mineral fertilizer input, for reason of the foregoing, the present work tries to investigate the scenario envisaged in the area. Organic materials directly and indirectly have significant effects on soil physical conditions. These effects are usually manifested in soils through aggregation which in turn influences the hydro-thermal properties of the soil and biochemical processes occurring in the soil as well as on root penetration. Lombin *et al.* (1991), observed that deterioration in the physical properties of Western Nigerian soil has occurred as a result of declining organic matter content in such soils, therefore addition of organic materials would go a long way in alleviating such adverse effect on the soil structure. The use of organic materials such as manure not only improves the soil physical condition in terms of its water holding capacity, aeration and drainage, but also enhances good root growth and development (Addiscott *et al*., 1992). Similarly, Manures are usually applied at higher rates, relative to inorganic fertilizers. When applied at high rate, they give residual effects on the growth and yield of succeeding crops (Makinde and Ayoola, 2008). Improvements of environmental condition as well as the need to reduce cost of fertilizing crops are reasons for advocating the use of organic materials as well as improve soil fertility by activating soil microbial biomass. Application of manure sustains cropping system through better nutrient recycling, Manures provide a source of macro and micro nutrient in available forms, thereby improving the physical and biological properties of the soil (Abou E1-Magd *et al*., 2006).

2.0 MATERIALS AND METHODS

2.1 Description of Experimental Site

An experiment was conducted in Research and Demonstration farm of the Lake Chad Research Institute in Maiduguri (11^0 54' N, 13^0 05' E), in order to study the nutrient uptake, growth and yield of sorghum as influenced by organic and inorganic fertilizers. The study site has an annual precipitation of 550.3 mm falling between late June and late September, with average monthly temperature of 28.5 – 32.8^0C, high temperature is recorded in the area in March to May and low temperature in November to February.

2.2 Treatments and Experimental Design

A 3 x 3 factorial experiment was laid out, comprising one sorghum variety (ICSV III), tested under three levels of FYM (0, 5.0 and 7.5 t/ha) and three levels of NPK (0, half and full dose of the recommended rates). The experiment was laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The resultant nine fertilizer treatment combinations comprised varying levels of FYM in combination with half (N_{32} P_{16} K_{15}) kg /ha and full (N_{64} P_{32} K_{30}) kg /ha the recommended rates of NPK fertilizer as listed below.

2.3 Treatments

$T_1 = N_0P_0K_0$) kg ha^{-1} (Control)

$T_2 = N_{32}P_{16}K_{15}$ kg ha^{-1}

$T_3 = N_{64}P_{32}K_{30}$ kg ha^{-1}

T_4 = 5.0 t ha^{-1} FYM

T_5 =7.5 t ha^{-1} FYM

T_6 = 5.0 t ha^{-1} FYM + $N_{32}P_{16}K_{15}$ kg ha^{-1}

T_7 = 5.0 t ha^{-1} FYM + $N_{64}P_{32}K_{30}$ kg ha^{-1}

T_8 = 7.5 t ha^{-1} FYM + $N_{32}P_{16}K_{15}$ kg ha^{-1}

T_9 = 7.5 t ha^{-1} FYM+ $N_{64}P_{32}K_{30}$ kg ha^{-1}

2.4 Agronomic Practices

The experimental site was harrowed and marked out into plots and blocks. Dimension of each plot was 5.25 m x 4.5 m at an alley between rows and plots of 0.5 m. Cow dung was incorporated to the plots according to the treatments requirement at two weeks before sowing. The inorganic fertilizer (NPK 15:15:15) was applied at the rate of 64 kg N/ha, 32 kg P/ha and 30 kg K/ha for the full dose and 32 kg N/ha 16 kg P/ha and 15 kg K/ha for half dose at sowing and the N and P requirement ware made up using urea (46% N) and SSP (18% P_2O_5) respectively at two weeks after sowing. The seed of sorghum variety (ICSV111), were sown in plots at a row spacing of 0.75 m apart and 0.3 m between stands in a row. Weeds was controlled manually using hand hoe, the plants were thinned to two plant per stand during the first weeding at 3 WAS. The second weeding was done at 6 weeks after sowing. According to (Agyenim *et al*., 2006), in an experiment with poultry manure and NPK, Agyenim et al. (2006), observed that the lowest poultry manure rate plus one-half rate of chemical fertilizer (i.e. 2 t/ha + ½ NPK) yielded significantly higher than the full rate of NPK alone. This implies that integrated application of organic and inorganic fertilizers might be more desirable than either type of fertilizers alone. In such cases, synergism might be at work. Vasanthi & Kumaraswamy (2000) reported that poultry manure plus one-half rate of the chemical fertilizer rate yielded significantly greater amount of green fodder of corn than the full rate of NPK alone. In another experiment on maize Ibrahim (1995), reported that the combined application of FYM at 5 t/ha and N fertilizer at 100 kg/ha showed significant effect on uptake by 3-fold increase and total dry matter yield by over 500% increase over control and the N-fertilizer application. The effect of manure alone was only appreciable at l0 t/ha rate and that of N-fertilizer at 120 kg/ha. A long term cropping studies in Kenya and Nigeria indicate that organic plus inorganic inputs could sustain soil fertility at a higher level than expected additive effects of either input (Kang and Balasubramanian, 1990).

2.5 Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA). The treatment means were compared using Duncan's multiple range test (DMRT) at 5% level of significance. The data were also subjected to correlation and regression analysis, in order to relate yield obtained in the different treatments to their respective NPK in plant samples, according to the procedure of Gomez and Gomez (1984), using computer software STATISTIX 8.0.

3.0 RESULTS AND DISCUSSION

3.1 Effects of Organic and Inorganic Fertilizers, and their Combinations on the Growth of Sorghum

3.2 Plant height at different periods

Table 1 shows the effects of the different levels of organic and inorganic fertilizers on the height of sorghum at 3, 6 and 9 weeks after sowing (WAS). Effect of the treatments was significant ($P<0.01$) on the growth of sorghum at all the three growth periods. Plant height at 3 WAS ranged from 7.4 to 27.1 cm and the lowest and highest were obtained from the control and 7.5t FYM + $N_{64}P_{32}K_{30}$, respectively. Application of 7.5t FYM + $N_{64}P_{32}K_{30}$ gave significantly higher growth than all other treatments, followed by 5.0t FYM + $N_{64}P_{32}K_{30}$. However, all applied fertilizer treatments gave significantly higher growth than the control, except 5.0 FYM. Similarly, Plant height at 6 WAS ranged from 18.9 to 57.6 cm, and application of 7.5t FYM + $N_{64}P_{32}K_{30}$ resulted in significantly higher growth than in any of the treatments. However, the height of sorghum that received 5.0t FYM + $N_{64}P_{32}K_{30,}$ 5.0t FYM + $N_{32}P_{16}K_{15}$, 7.5t FYM + $N_{32}P_{16}K_{15}$ and 7.5t FYM did not differ significantly ($P<0.05$). Similarly, growth in the control and 5.0t FYM treatment did not differ significantly as also was observed among $N_{32}P_{16}K_{15}$, 5.0t FYM and 7.5t FYM treatments. Result of sorghum height at 9 WAS ranged from 47.4 to 156.9 cm with the lowest and the highest obtained from control and 7.5t FYM + $N_{64}P_{32}K_{30}$, respectively. The treatment of 7.5t FYM + $N_{64}P_{32}K_{30}$, closely followed by 5.0t FYM + $N_{64}P_{32}K_{30}$ gave significantly higher growth than any of the other treatments. Application of 7.5t FYM +$N_{32}P_{16}K_{15}$ and 5.0t FYM + $N_{32}P_{16}K_{15}$ also gave significantly higher growth than all single sources of either organic or inorganic fertilizer treatment. All applied fertilizers resulted in significantly higher growth than the control. The result is in line with (Chroma *et al*.,2004).

Table 1. Effect of farm yard manure and inorganic fertilizers on the growth of sorghum at 3, 6 and 9 weeks' periods at Maiduguri

	Plant height (cm)		
Treatment	**3 WAS**	**6 WAS**	**9 WAS**
Control	7.4^{f}	18.9^{f}	47.4^{g}
$N_{32}P_{16}K_{15}$	13.1^{de}	30.7^{de}	84.0^{de}
$N_{64}P_{32}K_{30}$	14.0^{cde}	34.8^{cd}	92.7^{d}
5.0t FYM	10.3^{ef}	24.7^{ef}	69.7^{f}
7.5t FYM	11.5^{e}	29.1^{de}	79.8^{ef}
5.0t FYM + $N_{32}P_{16}K_{15}$	15.5^{cd}	36.8^{bcd}	105.9^{c}
5.0t FYM + $N_{64}P_{32}K_{30}$	21.2^{b}	40.1^{bc}	112.1^{c}
7.5t FYM + $N_{32}P_{16}K_{15}$	17.5^{bc}	44.9^{b}	133.3^{b}
7.5t FYM + $N_{64}P_{32}K_{30}$	27.1^{a}	57.6^{a}	156.9^{a}
SE±	1.28***	2.91***	3.61***

*Means in the same column followed by the same letter(s) are not statistically significant at 5% level of probability of the DMRT. ** Significant at 1% probability level of the F-test. WAS = Weeks After Sowing*

3.3 Effects of Organic and Inorganic Fertilizers, and their Combinations on Panicle, Straw, Total Dry Matter and Grain Yields in Sorghum

Table 2 shows the effect of different fertilizer treatments on four agronomic parameters in sorghum. Result shows that the fertilizer treatments differed significantly in their effects on the panicle weight, straw weight, total dry matter and grain yield ($p< 0.001$) of sorghum. Panicle weight among the different fertilizer treatments ranged from 372.5 to 3106.9 kg/ha. Panicle weight was significantly higher with application of 7.5t FYM + $N_{32}P_{16}K_{15}$, followed by 7.5t FYM + $N_{64}P_{32}K_{30}$ than other treatments. The 5.0t FYM + $N_{64}P_{32}K_{30}$ treatment gave higher panicle weight than the single sources; and 5.0t FYM + $N_{32}P_{16}K_{15}$ and 7.5t FYM were in turn gave significantly higher value than the control. However, there was no significant difference in panicle weight among $N_{32}P_{16}K_{15,}$ $N_{64}P_{32}K_{30}$ and the control. Straw weight ranged from 2398.6 to 5740.6 kg/ha among the different fertilizer treatments, with the lowest and highest values obtained from the Control and 7.5t FYM + $N_{64}P_{32}K_{30}$, respectively. Results did not show significant difference in the weight of straw among combined sources and $N_{64}P_{32}K_{30}$. Results further revealed that straw weights of all combined sources were statistically higher, but the single sources did not differ significantly from the control. Total dry matter ranged from 2771.1 to 8847.5 kg/ha, in which application of 7.5t FYM + $N_{64}P_{32}K_{30}$ was significantly higher than other treatments. This was closely followed by 7.5t FYM + $N_{32}P_{16}K_{15}$ and 5.0t FYM + $N_{64}P_{32}K_{30}$ with significantly higher dry matter yield than other single sources, $N_{32}P_{16}K_{15}$, $N_{64}P_{32}K_{30}$, 5.0t FYM and the Control.

Grain yield in the different fertilizer treatments ranged from 180.8 to 2051.6 kg/ha. The highest grain yield was obtained in treatment with application of 7.5t FYM + $N_{32}P_{16}K_{15}$, while the lowest yield was recorded where fertilizer was not applied (control). Combine application of 7.5t FYM + $N_{32}P_{16}K_{15}$ gave significantly higher yield than all the other treatments. This was followed by application of 7.5t FYM + $N_{64}P_{32}K_{30}$ and 5.0t FYM + $N_{64}P_{32}K_{30}$ which exerted similar effects, and significantly higher yield than the other treatments. Grain yield obtained in treatment with combine application of 5.0t FYM + $N_{32}P_{16}K_{15}$ was also significantly higher than those fertilized with single sources. However, the effects of $N_{64}P_{32}K_{30}$, 5.0t FYM and 7.5t FYM on yield did not differ significantly; as the case also was among $N_{32}P_{16}K_{15}$, $N_{64}P_{32}K_{30}$ and the control and the result was similar to the finding of (Awod *et al*., 2012).

Table 2. Effect farm yard manure and inorganic fertilizers on panicle weight, straw weight, total dry matter and grain yield of sorghum at Maiduguri

Treatment	Panicle weight (kg/ha)	Straw weight (kg/ha)	Total dry matter (kg/ha)	Grain yield (kg/ha)
Control	372.5^{g}	2398.6^{d}	2771.1^{e}	180.8^{e}
$N_{32}P_{16}K_{15}$	605.3^{g}	3851.9^{bcd}	4654.2^{d}	300.1^{e}
$N_{64}P_{32}K_{30}$	695.2^{fg}	4048.9^{abc}	4870.7^{cd}	361.1^{ed}
5.0t FYM	1134.4^{ef}	2582.0^{cd}	3830.7^{de}	607.4^{d}
7.5t FYM	1248.7^{de}	3826.5^{bcd}	4860.8^{cd}	607.4^{d}
5.0t FYM + $N_{32}P_{16}K_{15}$	1608.5^{cd}	4176.4^{abc}	5460.4^{bcd}	910.1^{c}
5.0t FYM + $N_{64}P_{32}K_{30}$	1909.0^{c}	4523.4^{ab}	6432.4^{bc}	1262.6^{b}
7.5t FYM + $N_{32}P_{16}K_{15}$	3106.9^{a}	4697.7^{ab}	7186.4^{ab}	2051.6^{a}
7.5t FYM + $N_{64}P_{32}K_{30}$	2488.9^{b}	5740.6^{a}	8847.5^{a}	1478.5^{b}
SE±	156.05**	569.08**	576.05**	88.02**

*Means in the same column followed by the same letter(s) are not statistically significant at 5% level of probability of the DMRT. ** Significant at 1% probability level of the F-test.*

3.4 Effects of Organic and Inorganic Fertilizers and their Combinations on Plant nutrient content

3.5 Leaf N, P and K content

Table 3 shows effects of the different fertilizer treatments on the content of N, P and K in the leaf of sorghum. The fertilizer treatments differed significantly (P<0.001) in their effects on the N, P and K content in sorghum leaf. N-content in the leaf ranged from 0.4667 to 1.8200%. The treatment, 7.5t FYM + $N_{32}P_{16}K_{15}$, closely followed by 7.5t FYM + $N_{64}P_{32}K_{30}$ had significantly higher N than all the other treatments. All the combined fertilizer treatments gave significantly higher leaf N-content than single fertilizer sources. However, all applied fertilizer treatments had significantly higher N-content in the leaf, than the control. The treatments also differed significantly (P<0.001) in their effects on P-content in the leaf of sorghum, which ranged from 0.1367 to 0.2367 %, obtained from the control and 7.5t FYM + $N_{32}P_{16}K_{15}$, respectively (Table 5). Application of 7.5t FYM + $N_{32}P_{16}K_{15}$ gave significantly higher leaf P-content than all the treatments. Similarly, 7.5t FYM + $N_{64}P_{32}K_{30}$ and 5.0t FYM + $N_{64}P_{32}K_{30}$ also gave significantly higher leaf P-content than all single sources; while the content in all fertilizer treatments was also higher than the control. Similarly, the effect of the treatments was also significant (P<0.001) on K content in the leaf, which ranged from 1.1500 to 2.9333%, Application of 7.5t FYM + $N_{32}P_{16}K_{15}$ gave significantly higher K-content in the leaf than any of the treatments. Combined fertilizer sources also resulted in higher leaf K-content than single sources; while the control had significantly lower K-content in the leaf than all treatments, which is tallied with the finding of (Azrafulhaq *et al*.,2004)

Table 3. Effect of farm yard manure and inorganic fertilizer on sorghum leaf NPK at Maiduguri

Treatment	N (%)	P (%)	K (%)
Control	0.4667^{e}	0.1367^{f}	1.1500^{i}
$N_{32}P_{16}K_{15}$	0.8667^{d}	0.1533^{e}	1.4867^{h}
$N_{64}P_{32}K_{30}$	1.0467^{cd}	0.1700^{d}	1.6033^{g}
5.0t FYM	1.0833^{cd}	0.1800^{cd}	1.7800^{f}
7.5t FYM	1.1900^{c}	0.1800^{cd}	2.0267^{e}
5.0t FYM + $N_{32}P_{16}K_{15}$	1.4400^{b}	0.1867^{bc}	2.2767^{d}
5.0t FYM + $N_{64}P_{32}K_{30}$	1.5667^{b}	0.2000^{b}	2.5100^{c}
7.5t FYM + $N_{32}P_{16}K_{15}$	1.8200^{a}	0.2367^{a}	2.9333^{a}
7.5t FYM + $N_{64}P_{32}K_{30}$	1.6767^{ab}	0.2000^{b}	2.6833^{b}
SE±	0.0812**	0.0048**	0.0320**

*Means in the same column followed by the same letter(s) are not statistically significant at 5% level of probability according to DRMT. ** Significant at 1% probability level of the F-test.*

3.6 Straw N, P and K content

Table 4 shows effects of the different fertilizer treatments on the content of N, P and K in the straw of sorghum. Results show that the fertilizer treatments differed significantly ($P<0.001$) in their mean straw N, P and K content. The result indicates that N content in the straw of sorghum ranged from 0.4167 to 1.9767%. The 7.5t FYM + $N_{32}P_{16}K_{15}$ treatment gave significantly higher N-content than all others, while all the combined fertilizer sources, except 5.0t FYM + $N_{32}P_{16}K_{15}$ also had higher N-content than single sources. The lowest straw N-content was obtained from the control, which however was statistically similar to content under $N_{32}P_{16}K_{15}$, $N_{64}P_{32}K_{30}$ and 5.0t FYM treatments. Similarly, P-content in the straw ranged from 0.0267 to 0.2767%; with the 7.5t FYM + $N_{32}P_{16}K_{15}$ treatment gave significantly higher straw P-content than all the other treatments. Similarly, sorghum straw obtained from 7.5t FYM + $N_{64}P_{32}K_{30}$ also had significantly higher P-content than the remaining treatments. On the other hand, the control gave the lowest P-content than any of the fertilizer treatments. Application of combined fertilizers resulted in higher straw P-content than single sources, however, P-content in the straw of sorghum that received 5.0t FYM + $N_{32}P_{16}K_{15}$ and 7.5t FYM were statistically at par.

K content in the straw ranged from 1.2300 to 2.6267%, with the lowest and highest values obtained from the control and 7.5t FYM + $N_{32}P_{16}K_{15}$, respectively. The K-content under 7.5t FYM + $N_{32}P_{16}K_{15}$ treatment was significantly higher than under all the other treatments, followed by 7.5t FYM + $N_{64}P_{32}K_{30}$ which was significantly higher than under the remaining treatments. All plot with organo-mineral fertilizer combination gave the best.The finding is in line with one reported by (Eifediyi. *et al*.,2020).

Table 4. Effect of farm yard manure and inorganic fertilizer on straw NPK at Maiduguri

Treatment	N (g/kg)	P (mg/kg)	K (Cmol/kg)
Control	0.4167^{f}	0.0267^{g}	1.2300^{h}
$N_{32}P_{16}K_{15}$	0.4700^{ef}	0.0667^{f}	1.3200^{g}
$N_{64}P_{32}K_{30}$	0.5600^{ef}	0.0767^{ef}	1.4533^{f}
5.0t FYM	0.6533^{def}	0.0867^{e}	1.7333^{e}
7.5t FYM	0.7700^{de}	0.0900^{de}	1.7833^{e}
5.0t FYM + $N_{32}P_{16}K_{15}$	0.9600^{cd}	0.1033^{d}	1.8867^{d}
5.0t FYM + $N_{64}P_{32}K_{30}$	1.2200^{c}	0.1267^{c}	2.1033^{c}
7.5t FYM + $N_{32}P_{16}K_{15}$	1.9767^{a}	0.2767^{a}	2.6267^{a}
7.5t FYM + $N_{64}P_{32}K_{30}$	1.6467^{b}	0.1500^{b}	2.2700^{b}
SE±	0.1034**	0.0054**	0.0287**

*Means in the same column followed by the same letter(s) are not statistically significant at 5% level of probability according to DRMT. ** Significant at 1% probability level of the F-test*.

3.7 Conclusion and Recommendations

3.7.1 Conclusion

Based on the results obtained it can be concluded that the application of 7.5t FYM + $N_{32}P_{16}K_{15}$ kg/ha, resulted in higher nutrient uptake, growth and acquisition of the highest yield of sorghum in the study area. However, application of 7.5t FYM + N64 P32 K30 kg/ha resulted in higher residual soil nutrient.

3.7.2 Recommendation

The application of 7.5t FYM + $N_{32}P_{16}K_{15}$ kg/ha is, therefore, recommended for sorghum production in the study area and similar experiment should be repeated in similar agro-climatic condition in order to confirm the findings

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