



EFFECT OF ORGANIC MANURE ON SORGHUM PRODUCTIVITY GROWN IN RESIDUAL MOISTURE IN BAKURA, NIGERIA

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ABSTRACT

Agriculture is mainly under rain-fed conditions in Zamfara State as the rainfall is very uncertain and temperature is increasingly high which is a major challenge and detrimental to crop growth and development. Therefore, climate risk management in agriculture (rainfed and residual moisture) is among the most important pillars of food security and resilience of agro-ecosystems. The objective of this study was to address residual farming system in Bakura area of Zamfara State. The experimental design was a dispersed randomized complete block design with 4 to 6 replications where each farmer was considered as a replication. The findings revealed that the treatment F7 (18 kg ha⁻¹ of NPK + 500 kg ha⁻¹ of organic manure gave the highest mean grain yield in 2012, 2013 and 2014; and the treatment F0 (0 kg ha⁻¹) gave the lowest mean grain yield.

Keywords: Climate Change, Crop growth, Flood recession farming, Organic manure, Residual moisture.

INTRODUCTION

Increasing crop production to meet the food security needs in Nigeria, like many African countries is the main goal to achieve. Nigeria has experienced accelerated demographic growth rate of more than 3% (Berthé *et al.*, 1991) while its agriculture is confronted with extremely difficult and changing climatic conditions. Climatic change plays a crucial role in resource depletion (Wezel and Rath, 2001) ending in failed crops or very low yields. However, the inundation of flat land by the Bakura lake is a great potential for the development of flood recession farming. Floods in this area result from local rain falling directly on the floodplain, or runoff from local streams mainly the surrounding hills. So, flood recession farming is an important component of the agricultural land of Bakura where low and unreliable rainfall does not guarantee success to rainfed agriculture. Flood recession agriculture is a traditional farming system practiced by farmers living along the lake. Floods reach the plains in July at the beginning of the rainy season and recede entirely in September. Planting takes place early in the seasonally inundated plain, following the receding flood water. Potentially, this area can be cropped after recession of flood waters.

Flood recession farming uses the residual soil moisture that is stored in the soil after annual inundation of floods plain, lake margins or seasonal wetlands (Saarnak, 2003) which brings nutrient-rich soil with it. Despite these global advantages, several constraints related to birds' damages, pest damages, flood insufficiency, low yields of crops, low level of equipment, low levels of certain nutrients such as nitrogen and organic matter exist. Among these constraints, organic matter appears to be one of the most limiting factors of crop production in the area.

Flood recession farming is an important livelihood activity for poor riparian communities in Africa and Asia. It utilizes residual moisture retained within the root zones of crops creating similar conditions like in irrigated farming system (Kashe *et al.*, 2015). This



farming system allowed planting of the most important and adapted crop of the area like sorghum. This crop cultivated in Bakura area, is confronted to unpredictable rains and floods because of climate change, over exploitation of soil without the use of fertilizer, low number of extension agent and poor equipment of farmers, leading to low yield during these last decennaries. Climate change constitutes nowadays a threat for environment and sustainable development. Poor communities will be the most vulnerable because of their limited adaptation capacity and their great dependence to climate sensitive resources such as water and production systems in general (Intergovernmental Panel on Climate Change [IPCC], 2007) and particularly in sorghum based cropping systems.

Sorghum (*Sorghum bicolor* (L.) Moench, belongs to the Tribe Andropogonae of the grass family Poaceae, cultivated for its grain, which is used for food, both for animals and humans, and ethanol production and originated from Africa. In most of the Asian and African countries, sorghum is mainly cultivated for human food (Berenji, 2004). The nutritional values of its grain were 70-80% of starch, 11-13% of protein, 2-5% of fat, 1-3% of fiber and 1-2% of ash (Adebiyi *et al.*, 2005; Khatir *et al.*, 2013). Sorghum is the world's fifth most important cereal crop after rice (*Oryza sativa*), Wheat (*Triticum aestivum* L.) maize (*Zea mays* L.) and barley (*Hordeum vulgare* L.).

In flood agriculture system, since organic matter and nitrogen were the main limiting factors for sorghum production, application of inorganic fertilizer can improve sorghum performance. However, chemical fertilizer is not affordable to local farmers, consequently, the use of organic manure became a great advantage, because it contains many nutrients required by plant for optimal performance and also helps in improving soil texture and structure (Pieri, 1989; Parr *et al.*, 1989). Organic manures essentially constitute of soil, they are present in variety of forms and it comprises of waste and residues from crops and livestock (Okoroafor *et al.*, 2013). The adequate use of organic manure in extensively cultivated area of flood recession plain can enhance crop production among several advantages. One of these adequate uses could be microdosing in opposition to former practice which broadcast fertilizer all over the field. Microdosing is cheapest, well adapted to millet and sorghum and allow a better fertilizer efficiency use and a sustainable increase of crop yield (Aune *et al.*, 2007), who reported yield increase of 34 to 52% compared to the control in Mali. Similar findings were mentioned by International Crops Research Institute for Semi-Arid Tropic (ICRISAT, 2015) who explained that 25 000 families in Mali, Burkina and Niger observed a substantial improvement of crop yield after a single apply of a pinch between three fingers, about 2 grams.

In Zamfara State in particular, few or no studies were conducted in flood recession system. Furthermore, indigenous knowledge on soil organic matter management in the region is not well known since the rule in the area is extensive agriculture practice. For these reasons, participatory on-farm research was conducted to study the influence of organic manure on sorghum crop performance.

MATERIALS AND METHODS

Experimental design

The experiment was conducted over a period of 3 years from 2015 to 2017 on-farm in farmers' fields around Natu Lake in the Bakura area of Zamfara State, Nigeria (12° 40' 9" N, 5° 53' 33" E). The experimental area of each experimental replication was 39 m by 5 m (195 m²). There were eight treatments per replication. Plot size of each treatment was 5m by 4 m (20 m²) with two border rows. Organic matter (OM) of 500 kg ha⁻¹ and mineral fertilizer (NPK containing respectively, 15 units of Nitrogen, 15 units of Phosphorus and 15 of Potassium and



Urea) were used. The average C:N ratio of the organic matter was 20, its average carbon content was 47.73%, nitrogen 1.73%, and its pH was 6.5.

Sorghum seeds were planted two (2) per hill at the depth of 15 cm with a spacing of 1m x 0.5 m. The treatments used in each replication were : 0 kg ha⁻¹ as a control (F0), 500 kg ha⁻¹ of OM (F1), 6 kg ha⁻¹ of NPK (F2), 12 kg ha⁻¹ of NPK (F3), 18 kg ha⁻¹ of NPK (F4), 6 kg ha⁻¹ of NPK +500 kg ha⁻¹ of OM (F5), 12 kg ha⁻¹ of NPK +500 kg ha⁻¹ of OM (F6) and 18 kg ha⁻¹ of NPK +500 kg ha⁻¹ of OM (F7). NPK and OM were applied at sowing in the same hill with seed but just near after covering seeds with soil to avoid negative germination effect on seed. 4 kg ha⁻¹ of urea (46% of nitrogen) were also applied 10 days after sowing in F2 to F7 treatments.

Local variety of sorghum (*Sorghum bicolor* L. Moench) called Jan jari in Hausa local language was used for all the experiment in agreement with farmers in order to understand their own sorghum response to fertilizer. During the growing period, experimental plot was weeded only one-time using hoes. Crops were harvested 12 weeks after sowing. Jan jari, kaura, natu lake

At harvest, total panicles, grain and stems sun dry weight were recorded as 1000 grains weight obtained with an electronic balance (METTLER 4000).

Statistical analysis

Analyses of variance of collected data were made using MINITAB statistical software (Release 14 for Windows) models. Effects of treatments were considered significant at the probability threshold of P<0, 05. Newman-Keuls test was used for significant mean differences between treatments.

RESULTS AND DISCUSSION

Sorghum Grain Yield

Average crop yield varied from 657 in 2015 to 1646 kg ha⁻¹ in 2016 (Table 1). Results revealed significant difference (P<0.001) among treatments. Over the 3 years, the treatments receiving compost or manure alone showed statistically higher yield (P = 0.001) than the control (+ 47%) which is the farmer practice. It appears also, that treatment F7 (18 kg ha⁻¹ of NPK + 500 kg ha⁻¹ of organic manure) gave the highest mean grain yield in 2015, 2016 and 2017, while treatment F0 (0 kg ha⁻¹) gave the least mean grain yield. The benefit compared to the control was 490 kg ha⁻¹ in 2015, 1668 in 2016 and 878 kg ha⁻¹ in 2017. In 2015, F7 was followed by F6 (12 kg ha⁻¹ of NPK and 500 kg ha⁻¹ of organic manure) which was statistically higher than the other treatments (F5, F4, F3, F2, F1), while it was statistically similar to them in 2016 and 2017.

Sorghum Straw Yield

Table 1 shows average straw yield, which varied from 2971 to 4398 kg ha⁻¹. Results showed that in 2015, there were significant difference (P<0.001) among treatments and F7 (18 kg ha⁻¹ of NPK and 500 kg ha⁻¹ of organic manure) gave the highest mean biomass yield. This was statistically similar to F6 and F5 (which combined mineral and organic manure) followed by F4, F3, F2, F1 while the control which is treatment F0 gave lower mean sorghum straw yield. Result revealed also no significant difference (p<0.98 in 2016 and 0.4 in 2017) among treatments while arithmetic mean straw yield was greater than 2015.

Thousand Sorghum Seeds Weight

Table 1 shows thousand grain weight (TGW) of sorghum from 2015 to 2017. The result indicates that treatment F7 (18 kg ha⁻¹ of NPK and 500 kg ha⁻¹ of organic manure) gave the



highest mean TGW while the F0 gave the least TGW. The benefit was, respectively, +21.5, +32 and +31.5% in 2015, 2016 and 2017. The results indicated that there were significant differences among treatments ($P < 0.0001$). In 2015, F7 was statistically similar to F6 and F5 which were followed by other treatments (F4, F3, F2, F1), while in 2016 and 2017, they were lower. Also, a significant decrease of the TGW was observed in 2016 and 2017 from the treatment F4 to F0.

Table 1: Effects of fertilization (Fert) on crop grain, straw yield (kg ha^{-1}) and thousand grain weight during 3 years

Year	2015			2016			2017		
Fert	Grain kg ha^{-1}	Straw kg ha^{-1}	TGW (g)	Grain kg ha^{-1}	Straw kg ha^{-1}	TGW (g)	Grain kg ha^{-1}	Straw kg ha^{-1}	TGW (g)
F0	497 ^d	1967 ^d	25.27 ^e	793 ^{bc}	4450	23.65 ^g	901 bc	3200	23.94 ^g
F1	562 ^{cd}	2790 ^{bc}	27.15 ^{de}	1451 ^b	4367	25.72 ^f	1214 b	3520	25.66 ^f
F2	555 ^{cd}	2672 ^c	27.9 ^{cd}	1163 ^b	4267	26.7 ^e	1001 ^{bc}	3253	26.86 ^e
F3	598 ^{cd}	2961 ^{bc}	28.36 ^{bcd}	1529 ^b	4517	27.8 ^d	1076 ^{bc}	3827	27.9 ^d
F4	623 ^c	3061 ^{bc}	29.08 ^{abc}	1630 ^b	4617	28.67 ^c	1249 b	3507	28.78 ^c
F5	643 ^c	3133 ^{abc}	29.68 ^{ab}	1905 ^{ab}	4033	29.55 ^b	1169 b	3387	29.7 ^b
F6	793 ^b	3420 ^{ab}	30.11 ^{ab}	2237 ^{ab}	4333	30.05 ^b	1288 b	3400	30.42 ^b
F7	987 ^a	3764 ^a	30.71 ^a	2461 ^a	4600	31.32 ^a	1779 a	3853	31.5 ^a
Pr	<0.001	<0.001	<0.0001	<0.001	0.98	<0.0001	<0.001	0.4	<0.0001
Mean	657	2971	28.53	1646	4398	27.93	1210	3493	28.09
SD	107	577	1.87	380	931	0.66	276	522	0.61
CV	16.2	19.4	6.5	23.0	21.1	2.3	22.8	14.9	2.1

a, b: values in the same column with different letters are significantly different at $P = 0.05$ SD: standard deviation (kg ha^{-1}), TGW: thousand grain weight, CV (%): coefficient of variation, Pr: Probability

Crop yield

As presented in Table 1, variation in yields between the three years can be attributed to the difference in the total rainfall since yields for crops grown on the floodplain are highly dependent on flood levels (McCartney *et al.*, 2010). Except 2015 where the combination of organic manure and microdose of mineral fertilizer out yielded the other treatment, sorghum straw yields didn't differ among treatment opposed to grain yields case. This can be explained by the valorization of fertilizer in the reproductive part of the plant at the expense of its vegetative parts. Sorghum dry biomass yields from the current study were lower than those of 12.85 t ha^{-1} reported by da Costa *et al.* (2015), when studying the effect of mulching on sorghum yield and biomass in flood recession agriculture which is an excellent alternative for sorghum production in the dry season. Sorghum 1000 grains weight was significantly different among treatments. This suggests that among the factors determining yield increase, a better grain filling leading to heavy grain can be cited.

CONCLUSION AND RECOMMENDATIONS

Results showed that sorghum grain yield is significantly greater in plots combining organic manure and microdose of mineral fertilizer. It appears that in flood recession



agriculture in Bakura, low yields in farmer's fields are mainly due to limited application of fertilizers. A fertilizer rate of 18 NPK + 500 OM gave a mean yield of about 1200 kg ha⁻¹ of sorghum. Results from this study are convincing factors for launching awareness activity for the majority of farmers who not apply chemical fertilizers in water recession agriculture. Training is needed to help develop low-cost improved technologies for better productivity of organic manure to increase crop performance. For example, this could include ways and when to harvest straw, implement, fill and follow up the compost pit.

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