Nigerian Journal of Soil Science 24 (2014) 72 – 79

Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

YIELD OF SORGHUM AND MILLET AS AFFECTED BY RICE HUSK – MULCH ON A SANDY LOAM SOIL IN MAIDUGURI, SEMI-ARID NORTH - EAST NIGERIA.

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ABSTRACT

A split-plot experiment with four replications was conducted at two sites in Maiduguri, Semi-arid North-East Nigeria to evaluate the influence of three rates of rice husk-mulch on the growth and yield of sorghum and millet on a sandy loam soil. Rice husk was uniformly applied on the soil surface of plots measuring 8 m x 4 m. Crop husbandry was carried out. After crop harvest, grain yield, stover yield, harvest index and panicle length were determined. Data collected were subjected to statistical analysis at 5 % level of significance. At Site 1, application of 10 and 15 t/ha mulch produced significantly ($P \leq 0.05$) higher grain yield than 0 t/ha mulch by 14.30 and 15.30 %, respectively. At the two sites, stover yield increased with mulch rate. At Site 1, application of 15 t/ha mulch resulted in a significantly ($P \leq 0.05$) lower (0.45) harvest index than 0 (0.65) and 10 (0.60) t/ha mulch rates. Application of 15 t/ha mulch produced significantly ($P \leq 0.05$) longer (26.35 cm) panicles than 0 (25.41 cm) t/ha mulch rate at Site 2.

Keywords: Rice husk-mulch, sorghum, millet, grain yield, stover yield, harvest index, panicle length and semi-arid region.

INTRODUCTION

The low and erratic distribution of rains in semi-arid regions coupled with high temperature, evapotranspiration rates and poor soil conditions imply that crops grown in such environments are often exposed to varying levels of water stress (Grema and Hess, 1994). Crop yields are often adversely affected by the scanty and highly variable rainfall. The problem of low crop yield is further aggravated by the low water storage capacity of sandy soils that dominate in most semi-arid environments (Yandev and Sachan, 1985; Rayar, 1988; Chiroma, 1996). A major challenge for improving crop yields without increases in rain water supply, therefore, is to minimize evaporation, make efficient use of the limited rainfall and enhance utilization of the stored water by crops. Sorghum (*Sorghum bicolor* (L.) Moench) and millet (*Pennisetum glaucum* (L) Br.) are important crops in Semi-arid regions of Nigeria, primarily as major staple food (Chiroma *et al.,* 2003; Ojeniyi *et al.,* 2009). In semi-arid regions, these two crops are only grown once a year under rain-fed condition. Rice husk faces less competition, especially, as livestock feed and material for construction, and could effectively be used as mulching material.

Management practices that maintain crop residue on the soil surface have been shown to increase yields (Akanbi and Ojeniyi, 2007). Chiroma *et al.,* (2005) reported that mulch application irrespective of tillage practice gave rise to significantly higher millet crop yield compared to zero mulch treatments. Higher yields were generally attributed to increased soil water content resulting from reduced evaporation and increased infiltration. Alhassan *et al*., (1998) noted that retaining crop residues such as grain straw on the soil surface have been especially effective in increasing moisture storage and crop yields in North-eastern Nigeria. Cultural practices that leave substantial amount of crop residues on the soil surface reduces soil moisture loss by evapotranspiration, eliminates surface crusting, increases infiltration and reduces surface runoff and soil loss while increasing crop yield (Cassel *et al*., 1995; Odofin, 2005). Sorghum yields were increased by 15 % as a result of retention of mulching material on the soil surface (Sow *et al.,* 1997). Linden *et al.* (2000) reported that residue retained on the soil surface increased maize grain and stover yields by 1 Mg ha^{-1} than no residue treatment. These researchers noted that these results apply primarily to soils in which the total water storage capacity and accumulated rainfall are insufficient to supply optimum available water to the crop throughout the growing season. The present study, therefore, is aimed at evaluating the effects of rates of rice husk-mulch on the yield of sorghum and millet in a rainfall limited environment.

MATERIALS AND METHODS

Description of the Study Area

Field trials were carried out at two sites located within the University of Maiduguri. Site 1 is located near Gate 2, in the Faculty of Agriculture Teaching and Research Farm (11^0 49´ N, 13^0 13´ E and 324 m above mean sea level), while Site 2 is situated in the Faculty of Agriculture orchard, opposite Centre for Arid Zone Studies complex (11^0 49´ N, 13^0 12´ E and 327 m above mean sea level). The two sites had been set aside exclusively, and found suitable for teaching and research purposes over a long period of time. The map of Borno State showing the location of the study area (Maiduguri) is shown in Fig. 1.

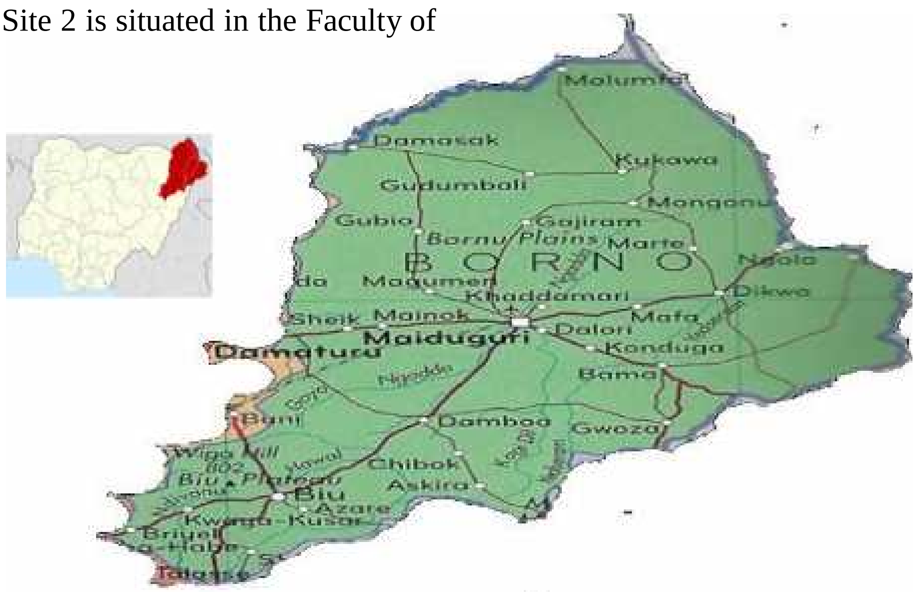

Figure 1: Map of Borno State showing the study area (Maiduguri)

The climate of the study area is the seasonal wet-dry, semi-arid type. The average annual rainfall ranges between 750 mm as observed during a ten-year period, 2000 to 2009 (Department of Meteorological Services, Maiduguri). Furthermore, potential evapotranspiration usually exceeds rainfall for about 8 to 9 months during a given year (Grema and Hess, 1994) except during the rainy periods. The soils of the study area are developed from Aeolian sand deposit. They are sandy loam in texture. The topography of Site 1 is characterized by gentle slope, while that of Site 2 is nearly level plain. The natural vegetation in the study area consists predominantly of grasses with few scattered trees and shrubs (Department of Forestry, University of Maiduguri).

Treatments and Experimental Design

The experiment was laid out in a split-plot design with test crops (sorghum and millet) as the main-plot, and the residue rates (0, 10 and 15 tons/ha) as the sub-plot treatments, giving a total of 6 treatments. The rates of residue application were assigned to the sub-plots at random. The treatments were replicated four times. The rates of residues (wheat straw and wood shavings) applied in the study area range between 4 and 10 tons/ha (Chiroma *et al.*, 2005; Chiroma, 2004).

Soil Sampling and Chemical Analysis

At the beginning of the experiment, one soil sample was collected from three replicates of each treatment at 0-15 cm and 15-30 cm depths. The soil samples were air-dried, passed through a 2 mm sieve and analyzed for physicochemical properties according to procedures described in detail by Page *et al.*, (1982). Also, a representative sample of the crop residue (rice bran) was analyzed in the laboratory for its N, P, Org. C, K, Ca, Mg and Na contents following the procedures described in IITA (1979).

Agronomic Practices

Rice bran-mulch was uniformly applied on the surface of plots measuring 8 m x 4 m, just before planting. Five to six Apron star treated sorghum (var. ICSV III) seeds were sown at a spacing of 40 cm within rows and 75 cm between rows, while millet (var. LCIC MV-2 (LCIC 9702)) seeds were sown at a spacing of 50 cm within rows and 75 cm between rows (BOSADP, 1993). The seedlings were thinned to two plants per stand two weeks after planting. Recommended fertilizer rate of NPK (64:32:30) kg/ha for sorghum and millet was applied in two split doses (BOSADP, 1993).

Weed control was carried out manually using hand-hoe at 2, 6 and 9 weeks after planting. Harvesting was done at physiological maturity.

Crop yield Parameters

The yield indices that were determined after crop harvest are grain yield, stover yield, harvest index and panicle Length. Grains and stover (above-ground dry matter) obtained from the net plot (6 m^2 and 4.5 m^2 for sorghum and millet, respectively) were weighed after thorough sun-drying following crop harvest. The length of panicles (from the base of the panicle to its tip) of ten plants randomly selected within the net plot after crop harvest was measured with the aid of a metre-rule.

Data Analysis

The data obtained were subjected to analysis of Variance. Duncan's Multiple Range Test (DMRT) was used to separate differences between means at 5% significant level.

RESULTS AND DISCUSSION

Physico-Chemical Properties of Soils of the Experimental Sites

The physicochemical properties of soils (0 – 15 and 15 – 30 cm soil depths) of Sites 1 and 2, and the chemical composition of rice husk (mulching material) are presented in Table 1.

The soils of the experimental sites are slightly acidic and sandy loam in texture. They are classified as Typic Ustipsamment (Rayar, 1986). At 0 – 15 and 15 – 30 cm depths, Site 2 exhibited higher electrical conductivity by 37 and 33 %, respectively, than Site 1. At 0 – 15 cm depth, Site 1 had higher organic carbon, organic matter and total nitrogen content (by 4, 5 and 12 %, respectively) than Site 2, while at 15 – 30 cm depth, Site 2 had higher values than Site 1 by 41, 41 and 42 %, respectively. At 0 – 15 cm, C/N ratio, avail. phosphorus, exchangeable calcium, magnesium, potassium, sodium contents, CEC, ECEC and base saturation were higher at Site 2 than at Site1 by as much as 3, 74, 61, 21, 51, 18, 48, 45 and 7 %, respectively. Similarly at 15 – 30 cm depth, avail. phosphorus, exchangeable calcium, magnesium, potassium, sodium contents, CEC, ECEC and base saturation were higher at Site 2 than at Site1 by 70, 39, 36, 52, 26, 39, 35 and 7 %, respectively. At 15 – 30 cm depth, C/N ratio at Site 1 was higher than at Site 2 by 2 %. Exchangeable acidity was higher by 8 % at Site 1 at 0 – 15 cm depth, whereas, at 15 – 30 cm depth, it did not differ between the two sites.

The organic matter content of these soils is low, and decreased with depth as expected. Their available phosphorus content is low, total nitrogen is moderate high and base status of these soils is low according to the ratings for soil fertility by FAO (1984; 2004) and Esu (1991). Generally, Site 2 soils possess higher clay content and higher nutrient status than those of Site 1. Soils with considerably high clay content are usually associated with higher nutrient and water-holding capacity compared with those high in sands. It is therefore, not surprising that soils at Site 2 performed better with respect to yield parameters, compared with soils at Site 1.

Table 1: Physico-chemical properties of soils of the experimental sites before cultivation and chemical composition of rice bran-mulch at Maiduguri, 2009

Parameters	Site 1	Site 2	Site 1	Site 2	Rice Bran (% Min. Content)
Soil Profile Depth, cm	0-15	0-15	15-30	15-30	
pH (1:2.5) in Water	6.25	6.20	6.33	6.34	
pH (1:2.5) in $CaCl_2$	5.56	5.69	5.71	5.76	
Electrical Conductivity, $\mu S\ cm^{-1}$	66.00	104.90	36.15	53.80	
Sand, $g\ kg^{-1}$	630.50	630.50	643.00	643.00	
Silt, $g\ kg^{-1}$	258.80	258.80	240.00	241.00	
Clay, $g\ kg^{-1}$	110.70	10.70	117.00	116.00	
Textural Class	SL	SL	SL	SL	
Organic Carbon, $g\ kg^{-1}$	5.00	4.83	2.78	4.68	2.52
Organic Matter, $g\ kg^{-1}$	8.62	8.33	4.79	8.07	5.04
Total Nitrogen, $g\ kg^{-1}$	2.58	2.30	1.30	2.23	0.19
C : N Ratio	2.02	2.08	2.13	2.10	12.99
Available Phosphorus, $mg\ kg^{-1}$	4.56	17.59	3.15	10.59	0.14
Exchangeable Calcium, $cmol\ kg^{-1}$	2.15	5.45	2.65	4.35	1.80
Exch. Magnesium, $cmol\ kg^{-1}$	1.50	1.90	1.35	2.10	1.73
Exch. Potassium, $cmol\ kg^{-1}$	0.64	1.31	0.49	1.03	0.03
Exch. Sodium, $cmol\ kg^{-1}$	0.46	0.56	0.48	0.65	0.04
Exch. Acidity ($H^+ + Al^{3+}$), $cmol\ kg^{-}$	0.70	0.65	0.95	0.95	
Cation Exch. Capacity, $cmol\ kg^{-1}$	4.75	9.22	4.97	8.12	
Effective C. E. C., $cmol\ kg^{-1}$	5.45	9.87	5.92	9.07	
Base Saturation, %	87.20	93.40	83.96	89.85	

Table 2: Effects of crop and mulch on the yield parameters of sorghum and millet at Maiduguri, 2009

	Grain yield (kg/ha)			Stover yield (kg/ha)			Harvest index			Panicle length (cm)		
Treatment	**Site 1**	**Site 2**	**Combined**	**Site 1**	**Site 2**	**Combined**	**Site 1**	**Site 2**	**Combined**	**Site 1**	**Site 2**	**Combined**
A: Crop Type												
Sorghum	2524.90a	5700.60a	4112.70a	3916.70a	8639.00b	6277.80b	0.68a	0.66a	0.67a	18.91b	23.56b	21.24b
Millet	2285.20a	3553.90b	2929.50b	5296.30a	10398.00a	7847.20a	0.45a	0.35b	0.40b	28.75a	28.10a	28.43a
SE±	256.34	481.86	140.47	703.43	276.22	334.37	0.03	0.05	0.04	0.63	0.37	0.47
B: Mulch rate												
0 t/ha	2189.20b	4116.40a	3152.80a	3722.20b	8427.00b	6074.60a	0.65a	0.49a	0.57a	23.89a	25.41b	24.65a
10 t/ha	2502.30a	4831.30a	3666.80a	4423.60b	10146.00a	7284.70a	0.60a	0.50a	0.55a	24.23a	25.74ab	24.98a
15 t/ha	2523.60a	4933.90a	3728.80a	5673.60a	9983.00a	7828.10a	0.45b	0.53a	0.49a	23.38a	26.35a	24.86a
SE±	123.52	506.93	573.42	338.58	484.04	1052.80	0.05	0.07	0.05	0.52	0.28	0.75
Interaction A x B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS

Mean with the same letter (s) in the columns are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level of probability.
* Sogmofocamt at 5% probability level
NS: Not Significant.

Table 3: Interaction effects of crop X mulch on panicle length (cm) of Sorghum and millet at site 2 at Maiduguri, 2009

	Crop type	
Mulch rate	**Sorghum**	**Millet**
0 t/ha	22.59c	28.24a
10 t/ha	23.70b	27.78a
15 t/ha	24.40b	28.30a
SE±	0.40	

Means with the same letter (s) in the columns are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Crop Yield Parameters

The crop yield parameters (grain yield, stover yield, harvest index and panicle length) of sorghum and millet are presented in Table 2, whereas the significant interaction relationship of crop type and mulch treatment on panicle length is presented in Table 3. At Sites 1 and 2, and in the combined data, the differences in yield parameters observed between sorghum and millet are attributed to inherent differences between the two crops. Results from this study indicate that, both 10 and 15 t/ha mulch application rates produced higher grain yield at Site 1, and higher stover yield at site 2, compared with zero mulch treatment.

Also at Site 1, sorghum and millet stover yield increased with mulch application rate. These observations in relation to differences among mulch treatments could be attributed to lower moisture loss, better microclimatic environment created by more adequate soil surface cover, higher crop leaf canopy cover, and higher soil organic matter and total nitrogen content under 10 and 15 t/ha mulch application rates at the two sites (Eze, 2014). For the same aforementioned reasons above, longer panicles resulted following the application of 15 t/ha mulch compared with zero mulch treatment at Site 2. Similar findings have been reported in which higher grain and stover yields were attributed to higher soil nutrient status (Linden *et al.*, 2000; Ojeniyi and Ighomrore, 2004; Ewulo, 2005; Akanbi and Ojeniyi, 2007; Ogban, 2009; Ojeniyi *et al.*, 2009). These workers noted that these results are commonly associated with soils with low water storage capacity and semi-arid regions, where rainfall is insufficient to supply optimum available water to the crop throughout the growing season. Naturally, the panicles of millet are longer than those of sorghum. Therefore, it is not surprising that, irrespective of mulch treatment, the combination of millet and all mulch treatments produced longer panicles than the combination of sorghum and the three mulch treatments at site 2. Also, higher soil organic matter and total nitrogen content under 15 t/ha mulch rate, and lower evaporative losses, better microclimatic environment created by more adequate soil surface cover under 10 and 15 t/ha mulch application rates at Site 2 (Eze, 2014) could be responsible for the longer panicles that resulted from the combination of sorghum and both 10 and 15 t/ha mulch rates, compared with those produced from the combination of sorghum and 0 t/ha mulch rate at Site 2. In this study, at Site 1, application of 15 t/ha mulch resulted in a lower ratio of sorghum and millet grain yield to the above-ground plant parts, than 0 t/ha mulch. The lower harvest index observed at Site 1 following the application of 15 t/ha mulch compared with zero mulch, indicate that a greater proportion of dry matter was accumulated in the above-ground plant parts, rather than in the grains in the 15 t/ha mulch treatment plots.

CONCLUSION AND RECOMMENDATIONS

From the findings in the present study, it is concluded that 15 t/ha mulch rate improved crop yield parameters in most cases at the two sites. Fifteen t/ha mulch application rate is, therefore, recommended for the production of higher stover yield at Site 1, and longer panicles at Site 2. Also, both 10 and 15 t/ha mulch application rates are recommended for the production of higher grain yield at Site 1, and higher stover yield at Site 2.

ACKNOWLEDGEMENT

The immense contributions, both morally and financially, of the Management of University of Maiduguri, Borno State and Federal University of Technology, Minna, Niger State, Nigeria are highly acknowledged.

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