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EFFECT OF BREWERY SPENT GRAIN ON THE GROWTH AND YIELD OF SORGHUM (*Sorghum bicolor* (L.) Moench)

EFECTO DE LA GRANJA GASTADA DE LA BREWERY EN EL CRECIMIENTO Y RENDIMIENTO DEL SORGO (*Sorghum bicolor* (L.) Moench)

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ABSTRACT

A field experiment was conducted at the Teaching and Research Farm, Ambrose Alli University, Ekpoma to investigate the effect of brewery spent grain on the growth and yield of sorghum. Treatment consisted of five rates of brewery spent grain (BSG) (0, 2, 4, 6 and 8 t/ha). The experiment was a randomized complete block design (RCBD) with three replicates. Sorghum variety (ABS 4540 AMZU) was used as a test crop. The parameters measured included: plant height, leaf area, number of leaves/plant at 3, 6 and 9 weeks after planting (WAP). Whole plant dry matter yield and grain weight were also determined. The results obtained showed that BSG treatments had significantly ($P<0.05$) higher plant height, leaf area and number of leaves than the control in all the weeks after planting, except for number of leaves at 3 WAP. At 3 and 6 WAP, the tallest plants (21.33 cm and 33.05 cm) were obtained from crops treated with 8 t/ha BSG while those treated with 6 t/ha BSG had the tallest plant (95.04 cm) at 9 WAP. 6 t/ha BSG recorded the highest leaf area at 3, 6 and 9 WAP. At 6 WAP, the highest number of leaves (9.00) was observed from plants which received the application of 6 t/ha BSG. However, control had the highest number of leaves (10.00) than BSG treatments. The highest grain yield (2.54 t/ha) and dry matter yield (3.80 g) were obtained from crops which received the application of 6 and 8 t/ha BSG, respectively.

RESUMEN

Se realizó un experimento de campo en la Granja de Enseñanza e Investigación, Universidad Ambrose Alli, Ekpoma, para investigar el efecto de la cerveza gastada en el crecimiento y el rendimiento del sorgo. El tratamiento consistió en cinco tasas de granos gastados de la cervecería (BSG) (0, 2, 4, 6 y 8 t / ha). El experimento fue un diseño de bloques completos al azar (RCBD) con tres repeticiones. Se usó la variedad de sorgo (ABS 4540 AMZU) como cultivo de prueba. Los parámetros medidos incluyeron: altura de la planta, área de la hoja, número de hojas / planta a las 3, 6 y 9 semanas después de la siembra (WAP). También se determinó el rendimiento de la materia seca de la planta entera y el peso del grano. Los resultados obtenidos mostraron que los tratamientos con BSG tuvieron significativamente (P <0.05) mayor altura de planta, área de hoja y número de hojas que el control en todas las semanas después de la siembra, excepto por el número de hojas a 3 WAP. A 3 y 6 WAP, las plantas más altas (21,33 cm y 33,05 cm) se obtuvieron de cultivos tratados con 8 t / ha BSG, mientras que las tratadas con 6 t / ha BSG tenían la planta más alta (95,04 cm) a 9 WAP. 6 t / ha BSG registró el área foliar más alta a 3, 6 y 9 WAP. A las 6 WAP, se observó el mayor número de hojas (9.00) de las plantas que recibieron la aplicación de 6 t / ha BSG. Sin embargo, el control tuvo el mayor número de hojas (10.00) que los tratamientos con BSG. El mayor rendimiento de grano (2.54 t / ha) y el rendimiento de materia seca (3.80 g) se obtuvieron de cultivos que recibieron la aplicación de 6 y 8 t / ha BSG, respectivamente.

INTRODUCTION

A number of factors are responsible for the low yield of crops. Among them, low organic matter content, poor fertility status, imbalanced use of high analysis chemical fertilizers accompanied by restricted use of organic manures that made the soils not only deficient in secondary and micronutrients, but also deteriorated the soil health (Akbari *et al*. 2011). Nutrients supply exclusively through chemical sources, though enhances yield initially, but the yields are not sustainable over the years. Application of mineral fertilizer continuously on the soils was found to reduce soil pH, microbial population and activities, organic matter content, buffering capacity and cation exchange capacity of the soils (Olomilua *et al*. 2007). Application of chemical fertilizers can also lead to potassium deficiency even with complex fertilizers including K (Wapa and Oyetola 2014). It is necessary therefore to look for another alternative way of improving the soil properties and quality for sustainable agriculture. Organic manures could ameliorate these adverse effects of inorganic fertilizers. It is a reservoir for various essential elements, a source of cation exchange capacity and soil buffering, and is a large geochemical reservoir of carbon (Bohn *et al*. 2001). Muhammad *et al.* (2001) reported that some of these spent grains can control plant pathogens. Crops wastes such as spent grain combined with poultry, cow and goat manures at equal rates were effective in increasing N and K concentration, growth and fruit yield than NPK Fertilizer (Ojeniyi *et al*. 2007).

Most developing nations continuously produce abundant agro-industrial residues such as brewer's spent grain (BSG), which are underexploited (Salihu and Muntari 2011). These wastes according to (Adediran *et al*. 2003) pose disposal and environmental problem. However, recent studies have shown that they are effective as manure for enhancing the yield of crops and nutrient status of soil (MoyinJesu 2003).

Brewer's spent grain is a by-product of brewing and can be utilized as organic fertilizer in a farmer's field for the replenishment of lost nutrients and to enhance soil aggregation. According to Tang *et al*. (2009) brewer's spent grains are of high nutritive value, it contains high protein content, cellulose, lignin and hemicelluloses. Mussato (2009) observed that xylose, arabinose and glucose are the most abundant monosaccharide found in brewer's spent grain. Also vitamins and minerals of different kinds and levels as well as amino acids have been identified in brewer's spent grain by Mussato and Roberto (2006) and Essien and Udotong (2008).With these characteristics, brewer's spent grain when used as an agro waste has the potentiality of improving soil productivity through the improvement of soil chemical, physical and biological properties.

Universally, grain crops are used in the brewery industries and sorghum is one such crops. The waste from sorghum after it has been used for beer production is known as sorghum based spent grains. Sorghum belongs to the family Poaceae. Sorghum is also known as guinea corn and it is a staple food in the drier parts of tropical Africa (Remison 2005).
Sorghum can be used as staple food in the drier parts of Nigeria. The grains can be ground into flour and used for porridge. The grains may be cooked like rice. It is widely used for brewing beer e.g. in South Africa. According to Mussatto (2009) during this process various residues and by-products are generated. The most common ones are spent grains, spent hops and surplus yeast, which are generated from the main raw materials known as sorghum.
Hence, this work was carried out to investigate the effect of brewery spent grain on the growth and yield of sorghum.

MATERIALS AND METHODS

The study area was experimental site of Teaching and Research Farm of Ambrose Alli University, Ekpoma, Edo State. Ekpoma is located in a forest – savanna transition zone of Edo State (Lat. 6^0 45' North and Long. 6^0 08' East) with a mean air temperature of 29^0C, relative humidity of 70%, sunshine of about 5-7 hours/day and mean annual rainfall of about 1200-1500 mm. The location experiences a wet season from April- November and dry season from December – March (Ighalo and Remison 2010). Soil samples were randomly collected at 0-15 cm depth with the aid of soil auger. The samples were thoroughly mixed to obtain a composite sample after which it was air dried at room temperature, sieved using a 2mm mesh sieve and bagged into polyethylene bag in readiness for laboratory analysis before planting. Brewery spent grain (BSG) used for this experiment was collected from Guinness Nigeria Plc, Benin City.

The experimental site measuring 8 m x 10 m manually was cleared, packed and delineated into plot sizes of 0.88 m x 2.25 m. Brewery Spent Grain (BSG) was applied at the rate of (0, 2, 4, 6 and 8 tons/hectare) to the plots and allowed to equilibrate for two weeks before planting. The experiment was laid out in a randomized complete block design (RCBD) with five treatments and replicated three times. A single sorghum variety known as ABS 4540 AMZU seed was used as a test crop and was planted two seeds per hole at a spacing of 25 cm x75 cm. Weeds were controlled manually with hoe at an interval of three weeks.

Soil samples were analyzed at the Nigerian Institute for Oil Palm Research (NIFOR), near Benin City for routine soil analysis. Soil samples were analyzed for particle size distribution; which was determined by the hydrometer method (Okalebo *et al*. 2002), soil pH was measured in a 1:1 (soil-water) by glass electrode pH meter (Mclean, 1982), organic carbon was done by wet dichromate acid oxidation method (Nelson and Sommers 1996), total nitrogen was determined by the micro Kjeldahl method (IITA 1989). Available phosphorus was extracted by Bray II solution and determined by the molybdenum blue method on the technician auto-analyzer as modified by Bray and Kurtz (1995), Al^{3+} and H^+ were extracted with 1N KCl (IITA 1989), Ca, Mg, Na and K were extracted with 1N NH_4OAC pH 7.0 (ammonium acetate). Potassium and sodium were determined with flame emission photometer while calcium and magnesium were determined with automatic adsorption spectrophotometer (IITA 1989). ECEC was calculated by the summation of exchangeable bases and exchangeable acidity (IITA 1989).

Growth parameters: Plant growth parameters were taken at three (3) weeks intervals after planting until crops were harvested.

Plant Height (cm): A measuring tape was used to measure the height of four (4) plants per plot from the soil surface to the tip of the crop where the youngest leaf branches (Omoregie and Nwajei 2015) and the average value was recorded.

Leaf Area (cm^2): A measuring tape was used to measure the length and breadth of the leaves of four (4) plants per plot and then multiplied by a constant 0.75 (Omoregie and Nwajei 2015) and the average value was recorded.

Number of leaves per plant: The number of leaves of four (4) plants per plot was visually counted (Omoregie and Nwajei 2015) and the average value was recorded.

Yield parameters: Yield parameters recorded were;
Grain weight: The weight of grains from four (4) panicles per plot after threshing was taken by using weighing balance (Omoregie and Nwajei 2015) and the mean value recorded.
Whole plant dry matter yield: The dry matter yield of the harvested four (4) plants per plot were determined by oven-drying at 70°C to a constant weight (Usman *et al*. 2017) and the mean value was recorded.

All data collected were analyzed statistically using analysis of variance (ANOVA) at 5% probability level and the means separated using Duncan’s Multiple Range Test (DMRT).

RESULTS AND DISCUSSIONS

Physical and Chemical Properties of Soil: The soil was sandy in texture, pH of 6.5 slightly acidic with sufficient available phosphorus of 26.47 mg/kg. However, the soil was low in total N, exchangeable Ca, K, Mg and ECEC. The result of the soil analysis showed that the only available phosphorus was above the critical nutrient element levels of 10 – 16 mg/kg as reported by (Adeoye and Agboola 1985) while other nutrient element were below the critical nutrient element levels given for most crops of this region as reported by (Adeoye and Agboola 1985). The above properties show that the soil was inherently poor in nutrients (Table 1) while the chemical properties of the brewery spent grain (BSG) used is shown in Table 2. The BSG had a pH of 5.8 which was moderately acidic.

Table 1: Physico-chemical properties of the soil before planting

Properties	Value
pH (H_2O)	6.50
Organic Carbon (g/kg)	7.09
Total N (g/kg)	1.21
Available P (mg/kg)	26.47
Exch. Ca^{2+}(cmol/kg)	2.48
Exch. Mg^{2+} (cmol/kg)	0.24
Exch. Na^{+} (cmol/kg)	0.24
Exch. K^{+} (cmol/kg)	0.05
Exch. H^{+}(cmol/kg)	0.20
Exch. Al^{3+}(cmol/kg)	-
ECEC (cmol/kg)	3.21
Particle size distribution	
Clay (g/kg)	45
Silt (g/kg)	22
Sand (g/kg)	933
Textural class	Sand

Table 2: Chemical Properties of the brewery spent grain used

Properties	Value
Ph	5.8
Organic carbon (%)	1.52
Nitrogen (%)	5.18
Phosphorus (%)	1.78
Potassium (%)	0.07
Calcium (%)	1.44
Magnesium (%)	0.58

Sorghum Growth and Yield: Brewery spent grain (BSG) application had significant effect on plant height throughout growth season (Table 3). At 3 weeks after planting (WAP), the application of 2 t/ha and 4 t/ha BSG were not significantly different from the control but the application 6 t/ha and 8 t/ha BSG were significantly ($P \leq 0.05$) higher compared to the control with the highest sorghum plant height of 21.33 cm recorded at the application of 8 t/ha BSG. At 6 WAP, the application of 4 t/ha and 6 t/ha BSG were not significantly different compared to the control but the application of and 2 t/ha and 8 t/ha BSG were significantly ($P\leq0.05$) higher compared to the control with the highest sorghum plant height of 33.05 cm recorded at the application of 8 t/ha BSG. At 9 WAP, the highest sorghum plant height was recorded at the application of 6 t/ha with a mean of 95.40 cm when compared to the control with a mean of 70.13 cm. It was observed that the application of spent grains increased the height of sorghum. The result was in agreement with the findings of Nsoanya and Nweke (2015) who reported increased in cereal (maize) height due to application of spent grain.

The application of BSG had significant ($P \leq 0.05$) increase on sorghum leaf area compared to the control throughout growth season. The highest sorghum leaf area was recorded at the application of 6 t/ha BSG in all the weeks after planting with a mean of 64.70 cm^2, 345.73 cm^2 and 402.57 cm^2 respectively (Table 4).

Table 3: Effect of BSG on Plant Height of Sorghum at 3, 6 and 9 Weeks after Planting (WAP)

Treatment (t/ha)	Plant Height (cm) Mean±SD		
	3 WAP	6 WAP	9 WAP
0	10.80± 0.72c	19.90± 1.65bc	70.13± 6.90b
2	9.50± 0.87c	15.33± 0.58d	93.70± 1.59a
4	11.30± 0.52c	18.00± 1.00cd	62.27± 0.86c
6	15.00± 3.61b	22.67± 2.08b	95.40± 0.61a
8	21.33± 1.26a	33.05± 2.93a	75.20± 3.14b

Means with same letter in the column(s) are not significantly different at 5% level.

Table 4: Effect of BSG on Leaf Area of Sorghum at 3, 6 and 9 Weeks after Planting (WAP)

Treatment (t/ha)	Leaf Area (cm^2) Mean±SD		
	3 WAP	6 WAP	9 WAP
0	29.25± 5.73e	149.50± 12.58d	239.77± 44.00c
2	20.28± 1.06d	122.47± 10.87e	178.02± 4.08d
4	43.28± 1.85c	194.84± 6.68c	226.96± 19.70c
6	64.70± 4.56a	345.73± 8.70a	402.57± 2.61a
8	56.70± 4.22b	242.35± 18.41b	321.34± 1.11b

Means with same letter in the column(s) are not significantly different at 5% level.

At 3 WAP, the application of all the levels of BSG had no significant difference in the number of leaves but the highest number of leaves was recorded at the application of 6 t/ha and 8 t/ha BSG with a mean of 6.67 At 6 WAP, the application of 2 t/ha, 6 t/ha and 8 t/ha BSG were significantly different from the control with the highest number of leaves of 9.00 recorded at the application of 6 t/ha BSG but the application of 4 t/ha BSG was not significantly different from the control. At 9 WAP, the applications of all the levels of BSG were significantly different from the control. All levels of application of BSG were not significantly different from each other and the highest number of leaves was recorded at the control with a mean of 10.00 (Table 5). The effect of brewery spent grain on sorghum dry matter yield (DMY) and grain weight are shown in Table 6.

Table 5: Effect of BSG on Number of Leaves of Sorghum at 3, 6 and 9 Weeks after Planting (WAP)

Treatment (t/ha)	Number of Leaves Mean±SD		
	3 WAP	6 WAP	9 WAP
0	5.67± 0.58	8.33± 0.58b	10.00± 0.00a
2	5.67± 0.58	6.00± 0.00d	7.33± 0.58b
4	6.33± 0.58	8.00± 0.00b	8.33±0.58b
6	6.67± 1.16	9.00± 0.00a	8.00± 1.00b
8	6.67± 0.58	7.33± 0.58c	8.33± 0.58b

Means with same letter in the column(s) are not significantly different at 5% level.

Table 6: Effect of BSG on the Dry Matter Yield (DMY) and Grain Weight

Treatment (t/ha)	Dry Matter Yield (DMY) (g) Mean±SD	Grain Weight(t/ha)
0	1.20± 0.0058e	1.25± 0.61d
2	3.07± 0.0058d	1.77± 0.55c
4	3.20± 0.0058c	1.82± 2.56c
6	3.73± 0.0058b	2.54± 1.76a
8	3.80± 0.0058a	1.92± 0.93b

Means with same letter in the column(s) are not significantly different at 5% level.

Sorghum dry matter yield and grain weight were significantly enhanced by the different levels of brewery spent grain. The applications of all levels of BSG were significantly different from the each other when compared to the control and the highest DMY was recorded at 8 t/ha BSG with a mean of 3.80g while application 6 t/ha BSG gave the highest sorghum grain weight of 2.54 t/ha but 2 t/ha and 4 t/ha was not significantly different from each other. DMY was found to increase with increase in BSG and this is in line with the report of Mbagwu and Ekwealor (1990) who reported increased plant height and dry matter of maize due to brewer's spent grain application while grain weight did not show a regular pattern of increase with increase in BSG. According to Vasanthi and Kumaraswamy (2000); Boating *et al*. (2006); Nweke and Nsoanya (2013) and Nweke *et al*. (2013) application of spent grain has synergistic and complementary effect on growth parameters and yield of maize.

The results of study revealed that sorghum treated with 6 t/ha BSG had the highest plant height (95.40 cm) and leaf area (402.57 cm^2) than other treatments. The control had higher number of leaves/plant than BSG treatments. Sorghum which received the application of 6 and 8 t/ha BSG gave the highest grain yield (2.54 t/ha) and dry matter yield (3.80 t/ha), respectively, while control had the least.

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