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GROWTH AND YIELD OF SWEET SORGHUM (*Sorghum bicolor* L.) AS AFFECTED BY THE DIFFERENT LEVELS OF BIO-SLUDGE

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Abstract

A study on the utilization of bio-sludge as organic fertilizer for sweet sorghum was conducted from October 2010 to April 2011 at the MMSU Experimental Station, Batac City, Ilocos Norte. It evaluated the potentials of bio-sludge as a source of organic fertilizer for sweet sorghum. The experiment was laid out in Randomized Complete Block Design with three replications. The treatments used were: T1 – control, no fertilizer application, T2 – recommended rate (RR) of inorganic fertilizer (80-30-30, NPK kg ha-1), T3 – recommended rate (RR) of bio-sludge (BS) (3.5 t ha-1), T4 – T2 + 25% RR of BS, T5–T2 + 50% RR of BS, and T6 – T2 + 75% RR of BS. Meanwhile, the parameters used to assess the effects of the treatments were plant height, stalk, panicle length diameter and length, grain yield ha-1, stalk weight, juice yield ha-1, juice sweetness, and bagasse weight.

Significant results were obtained in all the parameters measured except for the sugar content. Height, stalk, and panicle length, stalk and bagasse weight, and the juice yield of plants fertilized with the RR of inorganic alone (80-30-30, NPK kg ha-1) and with the addition of 25, 50 and 75% RR of BS were significantly higher than those applied with the RR of BS alone and the untreated ones while bigger stalk diameter resulted from the combination of higher amount of bio-sludge (50 or 75% RRBS) and inorganic fertilizer. Grain yield also increased by 35% when sweet sorghum was fertilized with the combination of higher amount of bio-sludge (50 or 75%) and inorganic fertili- zer; however, values were comparable with those applied with inorganic alone. Overall, using inorganic fertilizer at a rate of 80-30-30 kg NPK ha-1 was sufficient to improve the growth and yield of sweet sorghum. In addition, higher ROI was obtained in the same treatment. Although the application of bio-sludge did not contribute to the growth and yield of sweet sorghum, soil fertility was improved as manifested by the increase in %OM, %N, P and K.

Keywords: *Bio-sludge, organic fertilizer, soil fertility, grain yield, juice yield*

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Introduction

Replenishing the cultivated fields with nutrients and soil improving-materials ensures sustained soil fertility and ample harvests. This is mainly achieved by applying commercial fertilizers. Fertilizer is a substance added to soil to improve plant growth and yield. It replaces the chemical components that are taken from the soil by growing plants. It is also designed to improve the growing potential of soil and can create a better growing environment than natural soil. Moreover, it can be tailored to suit the type of crop that is being grown (http:// www.madehow.com).

According to Abd El-Aziz (2007), supply plant needs and improve the physical and chemical characteristics of soil such as its pH and structure. There is usually a dramatic improvement in both quantity and quality of plant growth when appropriate fertilizers are added. In Manahay's (2010) study on Tubang-bakod, all seedlings applied with commercial organic fertilizer survived unlike those of the unfertilized ones.

However, with the increasing cost of commercial fertilizers, the government has been spending million of dollars on imported inorganic fertilizers (Gicana, 1999; Gonzales, et al 2003). This is the reason why the prices of inorganic fertilizers in the local agricultural outlets are affected by the US dollar-PhP exchange rates, which consequently affect farmers' productivity.

As such, alternative approaches such as re-using of nutrients and soil-improving products from decomposed plants, and even from human excreta have been considered (Jonsson et al, 2004).

Human food contains considerable amounts of nutrients originating from plants. Only minute amounts of the plant nutrients are absorbed by and retained in the growing human body - the remainder leaving the body as excreta. The products of ecological sanitation, urine and feces, are in many ways well suited for use as fertilizers. The fertilizing effect of urine, just as that of chemical fertilizers is greater if the soil contains at least some organic matter. Urine is nutrient rich and feces are high in organic matter (Jonsson et al, 2004).

Schonning and Stenstrom (2004) reported that the conversion of human manure to humus is known as thermophilic (hot) composting, which involves the cultivation of heat-loving microorganisms in the composting process. These orga- nisms, which include bacteria and fungi, create an environment in the compost that destroys disease organisms in human manure, converting into a user-friendly, pleasant-smelling humus for food gardens.

Rich in nutrients, decomposed human manure is a valuable soil amendment that helps maintain fertility and increase crop yields. Compost provides a multitude of benefits. Humus in composts stabilizes the soil, reduces erosion, improves water-holding capacity and soil structure, and creates air spaces in the soil. Likewise, humus chelates some heavy metals and other contaminants and can act as a nutrient storehouse that slowly releases nutrients to plants (Schonning, et al, 2004).

Bio-sludge or human waste/excreta collected from septic tanks or sewage plants is a mixture of solid and liquid sediments. The rapid growing human population everywhere is inevitably creating problems due to the proper disposal of this potential pollutant. If not properly disposed, these wastes will contaminate not only the rivers but also the ground water table, which is an essential natural resource to humans.

In the Philippines, there are only few known service providers in collecting wastes from septic tanks, which do not even have the state-of-the-art sewage treatment plant that can fully process the waste into useful materials like organic fertilizers.

Applying sewage sludge to agricultural land has been widely practiced, especially in non-food crops through the years. Its utilization does not only complement the crop farming sector to increase crop productivity, but it also addresses the environmental concern for the proper disposal of bio-sludge by evaluating of its potentials as organic fertilizer to biofuel crops such as sweet sorghum. Additionally, using bio-sludge will minimize the country's dependence on imported oil-based fertilizers, because it is already available. Thus, a study was conducted to evaluate the potential of bio-sludge as source of organic fertilizer for sweet sorghum. Specifically, it determined the optimum levels of bio-sludge and inorganic fertilizer to increase grain and juice yield of sweet sorghum and assessed the economics of producing sweet sorghum using different fertilizer treatments.

Methodology

Locale of the study. The study was conducted at the MMSU Experimental Station, City of Batac, Ilocos Norte from October 2010 to April 2011. The area is a typical upland previously planted with rice and corn. The experimental area covers 1,332 sq m. The plot size was 17.5 sq m.

Research design and treatments. The experiment was laid out in Randomized Complete Block Design with three replications (Plate 1). The fertilizer treatments used were: T_1 – Control (No fertilizer application); T_2 – Recommended rate (RR) of inorganic fertilizer (80-30-30 NPK kg ha^{-1}); T_3 – RR of Bio-sludge (BS) (3.5 t ha^{-1}); T_4 – T2 + 25% RR BS; T_5 – T2 + 50 % RR BS; and T_6 – T2 + 75% RR BS. The inorganic fertilizer recommended rate of 80-30-30 NPK ha^{-1} or combined complete fertilizer (375 g $plot^{-1}$) and urea fertilizer (195 g $plot^{-1}$). Sweet sorghum variety SPV 422 was used.

Management Practices

Soil analysis. Composite soil samples were gathered from the experimental area before planting and after the removal of the standing crop. The soil samples were brought to the Department of Agriculture, Provincial Office, Laoag City for soil texture, pH, % OM, %N, P, and K analysis.

Application of treatments. The organic fertilizer treatments in T3, T4, T5, and T6 and complete fertilizer in T2, T4, T5, and T6 were applied as basal. The organic (bio-sludge) and complete fertilizers were applied in powdered form and were placed within the furrows before planting the sweet sorghum seeds. The urea fertilizer, on the other hand, was side dressed at 45 days after planting (DAP).

Care and maintenance. The experimental area was prepared thoroughly by plowing it twice to eradicate the emerging weeds and harrowed to

Plate 1. Experimental set-up showing the different treatments and panicles

pulverize the soil in time for planting. Furrows were set 70 cm apart and 15 cm deep. The seeds were sown via drilling. Overhead irrigation was done after planting to enhance germination. At the early vegetative growth stage (first six weeks), the plants were irrigated bimonthly, and weekly thereafter, especially during the panicle initiation up to seed maturity. Weeding was done monthly to avoid competition for moisture, nutrient, and solar radiation.

Data Gathering Procedure

Agronomic characteristics. Measurement of plant height, diameter and length of stalk was done at maturity period after cutting the sweet sorghum plants. Plant height was measured 0.50 cm above the ground to the panicle tip. The length of stalk was also measured after separating the panicle.

Yield and yield components. The panicle length and the stalk weight plot-1 were measured immediately after cutting the sweet sorghum plants while the bagasse weight and juice yield were measured separately after milling or extracting the juice using a portable cane mill. The grain yield plot-1 was weighed after threshing.

Percentage of sugar content. Using a refractometer, the brix reading of the sweet sorghum juice was obtained from the stalk.

Data Analysis. The various data sets gathered were subjected to analysis of variance for RCBD. Treatment means of parameters that showed significant results were compared using the Duncans' Multiple Range Test (DMRT) at 5% level of significance.

Results and Discussion

Soil Analysis

Table 1 shows the soil analysis results before applying the fertilizer treatments and after removing the sweet sorghum in the field. The soil texture before fertilizer application and after harvesting was heavy containing 55% clay, 30% silt, and 15% sand. There was a change in soil pH from slightly acidic to slightly alkaline (pH value ranged from 7.15 – 7.83), which according to Hoanh and Natividad (1987), is considered favorable for growing most plants. The %OM, %N, P (ppm) and K (ppm) contents were moderately increased by the application of RR of inorganic fertilizers (2.29, 0.093%, 27.19 ppm and 498.33 ppm, respectively). Meanwhile, those fertilizer treatments combined with bio-sludge include the following: RR inorganic + 25% RR BS (2.00%, 0.1%, 15.85 ppm and 478.30 ppm, respectively), RR inorganic + 50% RR BS (1.52%, 0.076%, 11.92 ppm and 464.47 ppm, respectively), and RR inorganic + 75% RR BS (1.44%, 0.072%, 18.90 ppm and 454.46 ppm, respectively). The treatment with no fertilizer and pure bio-sludge application did not increase the %OM (0.02%) and %N (0.006%) of the soil. The OM and P levels in all the treatments were deficient because they were below the adequate levels of 5% and 30 ppm respectively (Committee on Soil Fertility Management, 1999).

Agronomic Characteristics

Results revealed that the height of the sweet sorghum plants, their stalk length and diameter, as well as panicle length were significantly influenced by the different levels of bio sludge and inorganic fertilizer treatments (Table 2). Specifically, those plants applied with the recommended rate (RR) of inorganic fertilizer (80-30-30 kg NPK ha^{-1}) were the tallest (211.10 cm). However, comparable results were noted in treatments added with 25%, 50%, and 75% RRBS with similar values of 204.58, 210.85, and 210.82 cm, respectively. These were followed by plants applied with the RRBS (190.23 cm).

Table 1. Soil analysis before the application of treatments and after the removal of sweet sorghum in the field. MMSU, Batac, Ilocos Norte.

TREATMENT	TEXTURE	pH	OM,%	%N	P,ppm	K,ppm
Initial	Heavy	6.89	0.045	0.022	Trace	306.00
No Fertilizer	Heavy	7.68	0.02	0.006	2.79	374.34
RR Inorganic Fertilizer (80 -30-30)	Heavy	7.70	2.29	0.093	27.19	498.33
RR Bio-Sludge	Heavy	7.83	0.016	0.000	2.79	364.47
RR Inorganic + 25% RR Bio-Sludge	Heavy	7.28	2.00	0.100	15.85	478.30
RR Inorganic + 50% RR Bio-Sludge	Heavy	7.73	1.52	0.076	11.92	464.47
RR Inorganic + 75% RR Bio-Sludge	Heavy	7.15	1.44	0.072	18.90	454.46

Meanwhile, the unfertilized plants were the shortest (177.93 cm). On the other hand, the longest stalks at maturity period were exhibited by plants fertilized with the RR of inorganic + 50 % RR BS (179.88), but comparable lengths were obtained from those treated with RR inorganic + 75% RR BS (179.67 cm), RR inorganic fertilizer (179.15 cm) alone, and RR inorganic + 25% RR BS (173.75 cm). The shortest stalks were similarly recorded from the unfertilized plants (153.82 cm).

These results imply that plant height and stalk length of sweet sorghum were enhanced by applying the RR of inorganic fertilizer alone. This was manifested by the significantly shorter plants and stalks produced, which were exclusively applied with bio-sludge. Organic fertilizers may contain available nutrients, however, these may be released slowly and thus, did not immediately increase the height and stalk length of sweet sorghum. This corroborates with the findings of Legaspi and Malab (2013) on the delayed response of Tugui to organic fertilizer. After the conversion period on the first cropping year, the organic fertilizer effects were observed.

In terms of stalk diameter, sweet sorghum plants fertilized with the RR inorganic + 75% RRBS had the biggest stalk diameter (1.44 cm). The result, however, is comparable to those plants fertilized with the RR inorganic + 50% RR BS (1.37 cm). This was followed by the plants applied with the RR inorganic + 25% RR BS (1.36 cm), RR inorganic (1.35 cm), and RR BS (1.29 cm). The lowest stalk diameter was noted from the unfertilized plants. The results indicate that the addition of 50 to 75% of the RR BS to the RR inorganic fertilizer proved beneficial and met the nutrient requirement needed to increase the stalk diameter of sweet sorghum.

Table 2. Agronomic characteristics of sweet sorghum as affected by different bio-sludge levels and inorganic fertilizer treatments.

TREATMENT	PLANT HEIGHT (cm)	LENGTH OF STALK (cm)	DIAMETER OF STALK (cm)
	**	**	**
No Fertilizer	177.93^{c}	153.82^{c}	1.24^{d}
RR Inorganic Fertilizer (80-30-30)	211.10^{a}	179.15^{a}	1.35^{bc}
RR Bio-Sludge	190.23^{b}	164.38^{b}	1.29^{cd}
RR Inorganic + 25% RR Bio-Sludge	204.58^{a}	173.75^{ab}	1.36^{b}
RR Inorganic + 50% RR Bio-Sludge	210.85^{a}	179.88^{a}	1.37^{ab}
RR Inorganic + 75% RR Bio-Sludge	210.82^{a}	179.67^{a}	1.44^{a}
CV (%)	3.00	3.00	2.80

Means marked with the same letter within each column are not significantly different at 5% level of significance.

Panicle Length, Grain Yield, Stalk and Bagasse Weight and Juice Yield

Highly significant effects of the different levels of bio-sludge and inorganic fertilizer treatments were noted on the panicle length, grain yield (t ha-1), stalk and bagasse weight, and the juice yield (li ha-1) of sweet sorghum (Table 3). Plants fertilized with the RR inorganic + 75% RR BS had the longest panicles (32.60 cm) and consequently had the highest grain yield (14.78 t ha-1). Nevertheless, the result did not significantly vary from those plants fertilized with the same inorganic fertilizer level (31.95 cm and 13.22 t ha-1, respectively) and those added with 50% RR BS (31.65 cm and 13.53 t ha-1, respectively). The shortest panicles and lowest grain yield were exhibited by the unfertilized plants (24.12 cm and 9.19 t ha-1, respectively) and those treated with the RR BS alone (24.85 cm and 9.56 t ha-1, respectively).

Similarly, the stalk and bagasse weight of sweet sorghum were heaviest when fertilized with the RR inorganic + 75% RRBS (24.95 and 18.79 t ha-1, respectively). However, these were not significantly different from plants fertilized with RR inorganic plus 25% (24.00 and 18.50 t ha-1, respectively), 50% (24.19 and 18.15 t ha-1, respectively) and those applied with the RR inorganic fertilizer alone (22.95 and 16.96 t ha-1, respectively). The plants fertilized with the RR BS alone and those which were not applied with fertilizer generally registered the lowest values. The same trend was observed on the juice yield (L ha-1) of sweet sorghum. The highest juice yield (6,165.71 L ha-1) was produced by the plants applied with the RR inorganic + 75% RR BS. Comparable results, though, were obtained from plants fertilized with RR inorganic alone (5,992.38 L ha-1), and those which were added with 50% (6,041.90 li ha-1), and 25% RR BS (5,497 L ha-1).

It can be inferred from the results that the sweet sorghum panicle length, grain and stalk yield, bagasse weight, and juice yield were slightly increased by adding bio -sludge to the inorganic fertilizer applied. The results further imply that applying RR inorganic fertilizer alone (80-30-30 kg NPK ha-1) is enough to increase stalk yield, bagasse weight, and juice yield of sweet sorghum considering the comparable results and the costs incurred with the addition of the different bio-sludge levels. The findings are consistent with the previous results on agronomic characteristics, which further support the contention that organic fertilizer nutrients are released slowly. As such, they have not been fully utilized by the plants within the duration of the study. According to Silva (2011), the organic matter applied to the soil has to be mineralized or broken down by microorganisms first and its nutrients released to the soil as ions; thus, nutrients derived from organic fertilizer sources are not readily available to plants compared to the nutrients from soluble synthetic fertilizers.

Percentage Sugar (^{O}Brix)

The percent sugar content of sweet sorghum juice was not significantly affected by the different bio-sludge levels and inorganic fertilizer treatments used (Table 4). Numerically, however, the sugar content of sweet sorghum juice ranges from 16.50 to 19.67%. The highest numerical value was obtained from those treated with the RR inorganic + 50 % RRBS while the lowest was recorded from the unfertilized plants.

Table 3. Stalk yield, bagasse weight, juice yield, and grain yield of sweet sorghum as affected by different levels of bio-sludge and inorganic fertilizer treatments. MMSU, Batac, Ilocos Norte.

TREATMENT	PANICLE LENGTH (cm)	STALK YIELD (t ha^{-1})	WEIGHT OF BAGASSE (t ha^{-1})	JUICE YIELD (li ha^{-1})	GRAIN YIELD (t ha^{-1})
	**	**	**	**	**
No Fertilizer	24.12[b]	14.76[b]	11.00[b]	3763.81[b]	9.19[c]
RR Inorganic Fertilizer (80-30-30)	31.95[a]	22.95[a]	16.96[a]	5992.38[a]	13.22[ab]
RR Bio-Sludge (RRBS)	24.85[b]	13.24[b]	8.86[b]	4382.85[b]	9.56[c]
RR Inorganic + 25% RRBS	31.81[a]	24.00[a]	18.50[a]	5497.14[a]	12.60[b]
RR Inorganic + 50% RRBS	31.65[a]	24.19[a]	18.15[a]	6041.90[a]	13.53[ab]
RR Inorganic + 75% RRBS	32.60[a]	24.95[a]	18.79[a]	6165.71[a]	14.78[a]
CV (%)	3.10	5.60	8.10	9.90	7.30

Means marked with the same letter within each column are not significantly different at 5% level of significance.

Cost and Return Analysis

The estimated cost and return analysis of a 1-ha sweet sorghum using different levels of bio-sludge and inorganic fertilizer is shown in Table 5. As expected, the control or the unfertilized plants incurred the lowest expenditure (₱51, 950.00), while those plants applied with the RR inorganic + 75% RR BS had the highest expenditure (₱73, 429.00) due to the expenses incurred in purchasing the inorganic fertilizer and bio-sludge. The higher cost of production, however, was compensated by the higher gross income (₱320, 550.00) and net return (₱247, 121.00) brought about by the increased seed and stalk yield obtained from those applied with the RR inorganic + 75% RR BS. The utilization of the RR inorganic fertilizer in sweet sorghum production, however, would realize a profitable gain of 376.50% in return for every peso invested. This is higher by 39.96 % than the RR inorganic + 75% RR BS, by 49.78% than the inorganic + 25 % RR BS, by 50.36% than the inorganic + 50% RR BS, by 94.29% than the control, and by 186.31% than the inorganic + 25% RR BS.

Conclusions and Recommendations

Results revealed that sweet sorghum plant height, stalk length and diameter, and panicle length were influenced by the fertilizer treatments. Plant height, stalk, and panicle length were increased when plants were fertilized with the RR of inorganic fertilizer of 80-30-30 kg NPK ha-1 (211.10 cm) and by adding 75 (210.82 cm), 50 (210.85cm) and 25%

Table 5. Cost and return analysis of a 1-ha sweet sorghum farm, using different bio-sludge levels and inorganic fertilizers.

ITEM	TREATMENT					
	No Fertilizer	**RR Inorganic (80-30-30 NPK ha^{-1})**	**RRBS (3.5 t ha^{-1})**	**RR Inorganic + 25% RRBS**	**RR Inorganic + 50 % RRBS**	**RR Inorganic + 75% RRBS**
Materials						
1. Seeds	900.00	900.00	900.00	900.00	900.00	900.00
2. Fertilizer						
Complete		4,494.00		4,494.00	4,494.00	4,494.00
Urea		2,860.00		2,860.00	2,860.00	2,860.00
Bio-sludge			17,500.00	4,375.00	8,750.00	13,125.00
3. Gasoline & oil	29,000.00	29,000.00	29,000.00	29,000.00	29,000.00	29,000.00
Labor (Man-day)						
1. Land preparation	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00
2. Irrigation	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00	5,250.00
3. Application of fertilizer		1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
4. Weeding	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
5. Harvesting/Threshing	4,000.00	4,000.00	4,000.00	4,000.00	4,000.00	4,000.00
Rental						
1. Water pump	800.00	800.00	800.00	800.00	800.00	800.00
2. Land	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00	1,000.00
Total Production Cost	**51,950.00**	**60,304.00**	**70,450.00**	**64,679.00**	**69,054.00**	**73,429.00**
Income from Seeds@20 kg^{-1}	183,800.00	264,400.00	191,200.00	252,000.00	270,600.00	295,600.00
Income from Stalk@1 kg^{-1}	14,760.00	22,950.00	13,240.00	24,000.00	24,190.00	24,950.00
Gross Income	**198,560.00**	**287,350.00**	**204,440.00**	**276,000.00**	**294,270.00**	**320,550.00**
NET INCOME	**146,610.00**	**227,046.00**	**133,990.00**	**211,321.00**	**225,216.00**	**247,121.00**
ROI (%)	**282.21**	**376.50**	**190.19**	**326.72**	**326.14**	**336.54**

Complete fertilizer=₱1,059 bag^{-1}, Urea=₱1,100 bag^{-1}, Bio-sludge= ₱250 bag^{-1}, Seeds=₱150 kg^{-1}, Man-day = ₱250 day^{-1}

(204.58cm) of the RR BS. On the other hand, the biggest plant stalk diameter was obtained by adding 75% RR BS (1.44 cm); how- ever, that is comparable with those added with 50 % RRBS (1.37 cm).

Stalk and bagasse weight, and juice yield were consistently increased by applying the RR inorganic + 75% RRBS. However, comparable results on these parameters were obtained by the adding 25 to 50% RR BS and by applying the RR of the inorganic fertilizer alone. The highest grain yield was likewise produced by sweet sorghum plants applied with the combination of RR inorganic + 75% RR BS. That was not significantly different though from those plants added with 50% RR BS and those applied with RR inorganic fertilizer alone. No significant effect of the fertilizer treatments was noted on the percentage sugar content of sweet sorghum juice. The highest production cost was incurred by using RR inorganic + 75% RRBS, however, this was compensated by the higher gross income and net return obtained. Exclusively applying RR inorganic alone in sweet sorghum production would realize a higher profitable amount in return for every peso invested.

Based on the results, applying RR inorganic fertilizer alone at a rate of 80-30 -30 kg NPK ha-1 is sufficient to improve the growth characteristics and to increase stalk, grain, and juice yield of sweet sorghum. Although bigger stalk diameter resulted from the combination of higher amount of bio-sludge and organic fertili- zer, this did not significantly increase the juice and grain yield as compared to the plants applied with RR inorganic fertilizer alone. However, the effects of bio-sludge application in improving soil fertility as manifested by the increase in %OM, %N, P and K are indispensable. It is then suggested that higher amounts/rates of bio-sludge fertilizer be evaluated.

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