SVU-IJAS SVU-International Journal of Agricultural Sciences
Volume 4 Issue (3) pp.: 151-159, 2022
**Print ISSN 2636-3801 | Online ISSN 2636-381X**
Doi: 10.21608/svuijas.2022.156453.1226

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**RESEARCH ARTICLE**

# Response of sweet sorghum (*Sorghum bicolor* L. Moench) to the combined application of poultry litter and inorganic fertilizer

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## Abstract

Integrated nutrient management is one of the alternatives to inorganic fertilizer application to sustain ecological balance, and crop productivity and augment the cost of fertilizers. This study aimed to evaluate the response of sweet sorghum to the combined application of poultry litter and inorganic fertilizer on plant height, stalk length, stalk diameter, panicle length, panicle weight, 1,000-grain weight, and plot yield. This was conducted in a farmer's field at Cabadbaran City, Agusan del Norte, Philippines in 2021. The experiment was laid out in Randomized Complete Block Design (RCBD) with six treatments and three replications. The treatments were $T_1$- No fertilizer application (control), $T_2$- 120-40-45 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$ (Recommended Rate), $T_3$- 5 t $ha^{-1}$ poultry litter, $T_4$- 90-30-33.75 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$ + 1.25 t $ha^{-1}$ poultry litter, $T_5$- 60-20-22.5 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$ + 2.5 t $ha^{-1}$ poultry litter and $T_6$- 30-10-11.25 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$ + 3.75 t $ha^{-1}$ poultry litter. The combined application of poultry litter and inorganic fertilizer significantly affected the plant height, stalk length, stalk diameter, panicle length, panicle weight, and grain yield. The highest grain yield was recorded in plants applied with 3.75 t $ha^{-1}$ poultry litter + 30-10-11.25 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$ inorganic ($T_6$) but was comparable with the other poultry litter + inorganic fertilizer treatments. T6 gave the highest net income and return on investment of PhP 63,327.98 and 143.72 percent, respectively. It could be concluded that growing sweet sorghum was highly profitable when applied with a combination of poultry litter and inorganic fertilizer at the rate of 3.75 t ha-1 30-10-11.25 kg ha-1 N, P2O5, K2O.

**Keywords:** Inorganic Fertilizer; Poultry Litter; Sweet Sorghum.

## 1. Introduction

Food crops around the world have been vulnerable to climate change, specifically in tropical countries where most foods have been grown. The frequent occurrence of droughts, floods, earthquakes, and other environmental disasters associated with climate change resulted in low crop productivity. Developing alternative crops that can adapt to climate change is a significant step to avoid food scarcity.

Sweet sorghum (*Sorghum bicolor L. Moench*) is the world's fifth most abundant crop grain in terms of volume, trailing rice, corn, wheat, and barley (Petruzello, 2013). Morphologically it is similar to corn, however, its grain was on top rather than to the side. Sweet sorghum can grow 8 to 12 feet high and obtains 800 – 3,000 grains in each panicle cluster. It is considered an ideal smart crop because it is a major source of bioethanol that has been proven as an alternative solution to addressing the energy problem in the country, particularly in the Philippines which is heavily reliant on fuel importation to satisfy its energy requirement to feed the growing economic activity. Sweet sorghum also provides human food, livestock feed, forage, and organic fertilizer. Fuel, food, feed/forage, and fertilizer are the four Fs in sweet sorghum production that can help farmers increase their productivity. It was dubbed "the wonderful climatic crop" in

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*Received: August 15, 2022; Accepted: September 30, 2022; Published online: September 30, 2022.*

addition to being an ideal smart crop (Dela Cruz, 2009). This crop is considered a low-maintenance crop due to its resistance to insect pests, diseases, and weeds. It can survive in various soil types (Marx *et al.*, 2014); and persist in drought conditions better than corn (Dahiya, 2020). Planting sweet sorghum is profitable with its consistent positive gross margin and cost-effective in the long term. It has a higher biological yield than sugarcane which is attributed to its shorter life cycle (Reddy and Reddy, 2003). Although sweet sorghum is recognized as a resilient crop, low soil fertility is one of the primary barriers to achieving high productivity in sorghum cultivation. The steady decline in sorghum production observed over the years has been attributed to the decline in soil fertility (Denova and Casey, 1998; Muhammad *et al.*, 2018). Farmers' limited resources account for the limited use of inorganic and organic fertilizers in sorghum crops. They lack information on the appropriate combining ratio of organic and inorganic fertilizer in sorghum production, which leads to a significantly low yield. Likewise, soil degradation brought about by the loss of organic matter because of continuous cropping becomes aggravated particularly when inorganic fertilizers are solely applied repeatedly (FAO 2011). Several organic materials especially chicken manure, cow dung, and farmyard manure as soil amendments shown in most research works help in increasing crop production, particularly among subsistence farmers. However, the benefits derived from using organic materials have not been fully exploited for practical use as fertilizer mainly due to the large number of organic materials required to satisfy the nutritional need of the crop. Therefore, this study is carried out to determine the optimum fertilizer application rates and the best combination of organic and inorganic fertilizers for sorghum growth, development, and yield.

## 2. Materials and Methods

The experiment was conducted at the farmers' field in Purok 9, Barangay Sanghan, Cabadbaran City, Agusan del Norte, Philippines from March 1, 2021, to June 6, 2021. The experimental area is typical farmland previously planted with vegetables and corn. The experimental area of 301 $m^2$ was plowed and harrowed twice at the weekly interval to eradicate weeds and pulverized the soil. Furrows were set 70 cm apart at 15 cm deep. The experiment was laid in Randomized Complete Block Design (RCBD) with six (6) treatments and three replications. Experimental plot per treatment measures 4m x 3m (12$m^2$). Alleyways were constructed at 0.5m between plots and replications to facilitate data gathering and management. Treatment 1 (no fertilizer application) was designated as the control plot while $T_2$ – 120-40-45 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$ (Recommended Rate [RR]), $T_3$ – 5 t $ha^{-1}$ Poultry litter (PL), $T_4$ – 1.25 t $ha^{-1}$ PL + 90-30-33.75 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$ , $T_5$ – 2.5 t $ha^{-1}$ PL + 60-20-22.5 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$ and $T_6$ – 3.75 t $ha^{-1}$ PL + 30-10-11.25 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$

Ten (10) soil samples were randomly collected from the experimental area before land preparation. The collected soil samples were composited, air-dried, pulverized using a wooden mallet, and sieved through a 2-mm wire mesh. One kilogram of the composite soil sample and one kilogram of poultry litter were sent to the Regional Soil Testing Laboratory of the Department of Agriculture, Region 13 in Taguibo, Butuan City for the determination of soil texture, soil pH, % organic matter, N, P, K, Ca, Mg, Z, and S. Poultry litter and the complete fertilizer (14-14-14) in $T_2$, $T_3$, $T_4$, $T_5$, and $T_6$ were applied one day before seeding while urea (46-0-0) was applied 45 days after seeding. Sweet sorghum seeds of 242HT41 variety were sown by drilling on the furrows spaced at 70 cm between rows and 25 cm between hills with five seeds per hill. Thinning was done seven days after seed emergence at two plants per hill. Irrigation was done after sowing using a sprinkler to stimulate and enhance seed germination. Hand weeding was done three weeks after sowing and subsequent weeding operation was made to avoid crop-weed competition for moisture, nutrient, and solar radiation. Hilling up was done 30 days after sowing. For pest control and prevention, Karate 2.5 EC insecticide was sprayed at the rate of 1.5 tbsp./16L of water four times starting at 25 days after sowing until 60 DAS at a one-week interval to control fall armyworm infestation. Harvesting of the sorghum panicles was done at the maturity period. The plants in the harvestable particularly in the three middle rows were harvested excluding five end hills in each row. The harvested panicles were sun-dried, threshed, and cleaned. The threshed and cleaned grains were re-dried until 14% moisture content was achieved. Seeds were weighed for the determination of grain yield.

### ***2.1. Data gathered***

In agronomic characteristics, plant height was obtained at 30 DAS, 60 DAS, and 90 DAS. Ten plants were randomly selected at the three middle rows of each treatment plot. The height was measured using a meter stick from 0.50 cm above the ground up to the highest panicle tip. The stalk length and stalk diameter was obtained at harvest after the panicles were separated from the peduncle. Ten stalks were randomly selected to measure stalk length using a meter stick starting from the base of the stalk until the peduncle and a caliper was used in measuring its stalk diameter from the base of the stalk.

Furthermore, yield and yield components such as panicle length were obtained from ten randomly selected panicles during harvesting by using a meter stick from the peduncle's tip up to the panicle's tip while panicle weight was determined by harvesting ten panicles randomly selected within each treatment plot. The ten panicles were sun-dried until 14% moisture content was achieved, after which it was weighed individually using a digital weighing scale. Additionally, a weight of 1,000 grains was attained after the sweet sorghum panicles were threshed, sun-dried, and cleaned. 1,000 grains were counted from each treatment plot and weighed using a digital weighing scale whereas grain yield (t/ha) was determined by weighing the grains obtained from the harvestable area in each treatment plot. The grains were cleaned, sun-dried at 14% moisture content, and weighed. The yield was converted into tons per hectare basis using the formula:

$$\text{Grain yield (t ha}^{-1}\text{)} = \frac{\text{Plot yield (kg)}}{\text{Harvestable area (4.2 } m^2\text{)}} \times \frac{10{,}000\ m^2\ ha^{-1}}{1000\ \text{kg}\ t^{-1}}$$

The ratio of economic to biological yield (harvest index) was obtained by dividing the grain weight by total dry matter at harvest. The ten plant samples from each treatment per replication were cut close to the ground and the grains and straw were dried separately until 14% MC was obtained. After drying, the grains were weighed separately from the straw. Harvest Index was computed using the formula:

$$\text{HI} = \frac{\text{Economic yield}}{\text{Biological yield}} = \frac{\text{Dry weight of grains (g) (3 sample hills)}}{\text{Dry weight (g)of grains+dry straw yield (g) (3 sample hills)}}$$

Moreover, the cost and return analysis was determined by recording all the expenses incurred throughout the conduct of the study from land preparation up to harvesting. These include the cost of fertilizer and pest control, labor, and planting materials. Gross income was obtained per hectare by multiplying the grain yield with the current market price in kilograms. The gross margin and return of investment (ROI) were calculated using the formula below:

Gross margin = Gross Income- Total Cost of Production

$$\text{ROI (\%)} = \frac{\text{Net Return or Income/ha}}{\text{Total Production Cost/ha}} \times 100$$

### ***2.2. Statistical analysis***

All the data gathered were statistically analyzed using Statistix 10.0 Data Analysis Software and subjected to Analysis of Variance (ANOVA) in Randomized Complete Block Design. The Tukeys Test was used to compare the significance of the different treatment means at a 5% level of significance.

## 3. Results and discussion

Fifteen (15) DAS weeds resurgence was observed, and it was dominated by carabao grass (*Paspalum conjugatum*), Creeping panic grass (*Brachiaria reptans*), and colitis or pigweed (*Amaranthus retroflexus, Amaranthus viridis)*. However, sweet sorghum was not affected as timely weeding was done in the experimental area. After twenty-five (25) DAS fall armyworm (larvae) infestation was observed but was repelled by the application of Karate 2.5 EC insecticide with an application rate of 1.5 tbsp/16L of water was applied four times at one-week intervals until the full emergence of the panicle. One month after sowing variation in the growth and development of sweet sorghum was observed from each treatment. Plots treated with poultry litter and inorganic fertilizer were greener and taller compared to untreated plots.

Plots applied with 3.75 t $ha^{-1}$ PL + 30-10-11.25 kg $ha^{-1}$ N, $P_2O_5$, and $K_2O$ ($T_6$) manifested better agronomic characteristics such as plant height, greener leaves, and stem diameter. The untreated plots ($T_1$) were stunted, had pale leaves, and has a thinner stem. At the ripening stage, false smut was noticeable, as high humidity has been perceived.

### *3.1. Soil and poultry litter analysis*

The soil in the experimental area and poultry litter were subjected to a chemical test to determine the nutrients present and the fertilizer recommendation for the study. The soil chemical test and fertilizer recommendation report show that the samples submitted show Soil Test Data of soil texture - heavy, soil pH – 6.99, % OM – 1.2, and thus NPK recommended rate of 120 – 40 – 45 was adopted. The chemical test for poultry litter revealed that the moisture content has 10.22%. The amount of N, K, and P were 4.48%, 3.66%, and 4.46%, respectively, while the micronutrients present in the poultry litter were as follows: Ca- 3.08%, Mg- 8452 ppm, and Zn- 198 ppm.

### *3.2. Agronomic characteristics*

Statistical analysis revealed that all agronomic parameters were significantly affected by the treatments used compared to the control (Table 1). Fertilizer application significantly increased the plant height of sweet sorghum. The tallest plants at 30, 60, and 90 DAS were observed in plots applied with 3.75 t $ha^{-1}$ + PL 30-10-11.25 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$ inorganic fertilizer ($T_6$). Nevertheless, plants applied with combined poultry litter and inorganic fertilizer at different rates ($T_4$ and $T_5$), and those that received 5 t $ha^{-1}$ of poultry litter alone ($T_3$) and inorganic fertilizer at the recommended rate ($T_2$) had statistically similar plant height from 30-90 DAS with that of $T_6$ (3.75 t $ha^{-1}$ PL + 30-10-11.25 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$ inorganic fertilizer). The shortest plants were recorded on the unfertilized plants. Such finding conforms to the study of Azraf-ul-Haq *et al.* (2007) that a combination of organic and inorganic fertilizer significantly increased the plant height of sweet sorghum resulting in taller plants compared to the unfertilized plants. According to Bhatt *et al.* (2019) application of farm manures and inorganic fertilizer will enhance productivity and improve soil physicochemical properties that play a vital role in soil and crop health for long-term productivity. Culm length is one of the parameters that are important in sweet sorghum production. The taller the culm the higher biomass is expected which makes it ideal for biofuel production. In the study, an almost similar trend relative to plant height was observed for the culm length. Sweet sorghum applied with 5t $ha^{-1}$ poultry litter ($T_3$) and inorganic fertilizer ($T_2$- 120-40-45 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$) singly had a taller culm length than the unfertilized plants ($T_1$). On the other hand, the combination of poultry litter and inorganic fertilizer ($T_4$-$T_6$) resulted in a comparable culm length, which was taller than the unfertilized plants ($T_1$). The result implies that the combination of poultry litter and inorganic fertilizer could be a valuable option for sweet sorghum farmers considering the availability and cost of the poultry litter and inorganic fertilizer in the locality. A field trial conducted by Mekdad and El-Sherif (2016) showed that the application of inorganic fertilizer influenced the culm length of sweet sorghum. Another important parameter for sweet sorghum production is the culm diameter. Generally, fertilized plants ($T_2$-$T_6$) had significantly bigger culm than the unfertilized ones ($T_1$). At 30 DAS, the biggest culm was observed in $T_6$ applied with a combined application of poultry litter and inorganic fertilizer at 3.75 t $ha^{-1}$ PL + 30-10-11.25 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$ but this was comparable with the other fertilized plants ($T_2$-$T_5$). Closer to harvesting (90 DAS), the biggest culm was recorded in $T_5$ at 21.40 cm. Such findings did not statistically differ from the other plants that received organic (PL) and inorganic fertilizers applied singly ($T_2$ and $T_3$) or in combination. Mekdad and El-Sherif's (2016) field trials also confirmed that inorganic fertilizer application gave a significant increase in culm diameter per plant to 17.88% and 7.18% over the unfertilized plants. This also conforms to the study of Ismael *et al.* (2012) that chicken manure significantly affected the stem diameter at 21 DAS and during the harvest of sorghum. The result implies that the application of poultry litter at 2.5 t $ha^{-1}$ + half of the inorganic fertilizer recommendation can enhance and support the vegetative growth of sweet sorghum.

**Table 1.** Agronomic characteristics of sweet sorghum as influenced by the combined application of poultry litter and inorganic fertilizer.

| | Plant height (cm) at | | | Culm length (cm) | Culm diameter (mm) at | | |
|---|---|---|---|---|---|---|---|
| Treatment | 30 DAS | 60 DAS | 90 DAS | | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | $78.63^{b}$ | $138.08^{b}$ | $143.57^{b}$ | $119.63^{b}$ | $9.15^{b}$ | $16.07^{b}$ | $17.93^{b}$ |
| $T_2$ | $86.88^{ab}$ | $162.05^{a}$ | $162.47^{a}$ | $131.78^{a}$ | $13.10^{a}$ | $17.93^{ab}$ | $19.57^{ab}$ |
| $T_3$ | $94.48^{a}$ | $160.90^{a}$ | $160.13^{a}$ | $128.34^{ab}$ | $15.30^{a}$ | $19.83^{a}$ | $22.33^{a}$ |
| $T_4$ | $92.45^{a}$ | $160.17^{a}$ | $159.4^{a}$ | $129.49^{a}$ | $15.17^{a}$ | $19.57^{ab}$ | $21.93^{ab}$ |
| $T_5$ | $85.55^{ab}$ | $162.95^{a}$ | $161.33^{a}$ | $127.13^{ab}$ | $14.80^{a}$ | $21.40^{a}$ | $24.17^{a}$ |
| $T_6$ | $96.75^{a}$ | $166.00^{a}$ | $164.67^{a}$ | $132.65^{a}$ | $16.13^{a}$ | $19.20^{ab}$ | $24.67^{ab}$ |
| Mean | 89.11 | 158.36 | 158.59 | 128.17 | 13.94 | 19.00 | 21.77 |
| C.V. | 4.87 | 2.00 | 1.59 | 2.52 | 9.81 | 6.58 | 11.83 |

*Column(s) having the same letter(s) are not significantly different from each other at a 5% level of significance, HSD*

Legend:

$T_1$ – Control (No fertilizer)

$T_2$ – 120-40-45 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$ (Recommended Rate [RR])

$T_3$ – 5 t $ha^{-1}$ Poultry litter (PL)

$T_4$ – 1.25 t $ha^{-1}$ PL + 90-30-33.75 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$

$T_5$ – 2.5 t $ha^{-1}$ PL + 60-20-22.5 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$

$T_6$ – 3.75 t $ha^{-1}$ PL + 30-10-11.25 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$

### *3.3. Yield and Yield Components*

The yield and yield components of sweet sorghum as influenced by the combined application of poultry litter and inorganic fertilizer revealed that panicle length and weight and grain yield were statistically influenced by the fertilizer treatments (Table 2). Interestingly, plants fertilized with combined poultry litter and inorganic fertilizer at 2.5 t $ha^{-1}$ PL + 60-20-22.5 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$ ($T_5$) had the longest panicle length (30.72 cm) which significantly differed from those fertilized with the recommended rate of inorganic fertilizer ($T_2$). Moreover, statistically, longer panicles were observed in treatments with combined poultry litter ($T_4$ and $T_6$) and inorganic fertilizer compared to the control ($T_1$). Elamin and Madhavi (2015) found that panicle length was significantly influenced by farm manure and vermicompost at 2.5 tons per hectare, which gave the highest value of 37.57 cm.

For the weight of panicles, the combination of 2.50 tons $ha^{-1}$ poultry litter and inorganic fertilizer at 60-20-22.5 kg $ha^{-1}$ N, $P_2O_5$, and $K_2O$ in $T_5$ produced heavier fresh and dry panicle weight at 125.33 g and 83.30 g, respectively compared to the control ($T_1$). Furthermore, regardless of treatments, all fertilized plants did not statistically differ in fresh and dry weight basis, which were heavier than the control. This could be attributed to the available nutrients from the fertilizers applied. Ayu *et al.* (2013) concluded that sweet sorghum treated with 10, 20, and 30-ton $ha^{-1}$ of animal manure increased the fresh weight of panicles per hectare.

Analysis of variance on the weight of 1,000 grains of sweet sorghum was not significantly affected by the conventional and combined fertilization using poultry litter and inorganic fertilizer. The result on the weight of 1,000 grains is similar to the findings of Getahun *et al.* (2016) that application of farmyard manure and recommended inorganic fertilizer did not influence the 1,000-grain weight of sweet sorghum, as grain weight was genetically controlled by its trait. In contrast, Alemayehu *et al.* (2016) reported that the application of organic and inorganic fertilizer has increased the kernel weight per head as attributed to vigorous plant growth and development compared to unfertilized plants.

**Table 2.** Yield and yield component and harvest index of sweet sorghum as influenced by the combined application of poultry litter and inorganic fertilizer.

| Treatment | Panicle length (cm) | Panicle weight (g) | 1,000-grain weight (g) | Grain yield (t $ha^{-1}$) | Harvest index |
|---|---|---|---|---|---|
| $T_1$ | $24.19^{c}$ | $38.77^{b}$ | 24.67 | $4.22^{b}$ | $6.58^{b}$ |
| $T_2$ | $27.32^{b}$ | $64.13^{a}$ | 25.33 | $6.77^{a}$ | $7.34^{ab}$ |
| $T_3$ | $29.09^{ab}$ | $75.70^{a}$ | 26.67 | $8.00^{a}$ | $7.60^{ab}$ |
| $T_4$ | $28.34^{ab}$ | $69.40^{a}$ | 25.67 | $7.10^{a}$ | $7.09^{ab}$ |
| $T_5$ | $30.72^{a}$ | $83.30^{a}$ | 25.33 | $7.46^{a}$ | $7.69^{a}$ |
| $T_6$ | $29.57^{ab}$ | $77.13^{a}$ | 26.67 | $8.95^{a}$ | $7.74^{a}$ |
| Mean | 28.21 | 68.07 | 25.72 | 7.08 | 7.35 |
| C.V. | 3.73 | 10.73 | 4.9 | 10.97 | 5.18 |

*Column(s) having the same letter(s) are not significantly different from each other at a 5% level of significance, HSD*

Legend:

$T_1$ – Control (No fertilizer)
$T_2$ – 120-40-45 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$ (Recommended Rate [RR])
$T_3$ – 5 t $ha^{-1}$ Poultry litter (PL)
$T_4$ – 1.25 t $ha^{-1}$ PL + 90-30-33.75 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$
$T_5$ – 2.5 t $ha^{-1}$ PL + 60-20-22.5 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$
$T_6$ – 3.75 t $ha^{-1}$ PL + 30-10-11.25 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$

Numerous studies found that applying fertilizers could increase the yield of sweet sorghum. Pallavi *et al.* (2020) mentioned that the use of organic manures and inorganic fertilizer gave a significant effect on yields compared to untreated plants. The result of the study revealed that the combination of 3.75 t $ha^{-1}$ PL and 30-10-11.25 kg $ha^{-1}$ N, $P_2O_5$, and $K_2O$ inorganic fertilizer ($T_6$) gave the highest grain yield of sweet sorghum at 8.95 t $ha^{-1}$. Yield differences among the fertilized plants, however, did not statistically differ from each other. On the other hand, $T_1$ (no fertilizer) gave the lowest yield of 4.22 t $ha^{-1}$. This implies that a combination of poultry litter and inorganic fertilizer can increase the yield of sweet sorghum. For the harvest index, fertilized plants did not statistically differ in their harvest index, which was relatively higher than the unfertilized plants.

### *3.4. Cost and return analysis*

The cost and return analysis of sweet sorghum as influenced by the combined application of poultry litter and inorganic fertilizer is presented in Table 3.

The economic analysis of the data presented in Table 3 depicted that the highest gross margin of PhP63,327.98 was observed in $T_6$ applied with 3.75 t $ha^{-1}$ PL + 30-10-11.25 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$ followed by $T_3$, $T_5$, $T_4$, and $T_2$, whereas $T_1$ gave the lowest gross margin of PhP8,919.05. These results indicated that the application of poultry litter and inorganic fertilizer could increase farmers' yield and income. The result implies that $T_6$ is essentially the best choice under the conditions of the study.

The result showed the potential of sorghum production in Agusan del Norte as observed in the study. Unfertilized plants ($T_1$) gave the lowest return of investment among all treatments with 21.39% lower than $T_6$, which gave the highest ROI at 143.72%. The result showed that the combined application of poultry litter and inorganic fertilizer in sorghum increased the productivity and profitability of sorghum production in Agusan del Norte.

**Table 3.** Cost and return analysis of sweet sorghum as influenced by the combined application of poultry litter and inorganic fertilizer.

| Treatment | Yield (t/ha) | Gross Income (PhP) | Production Cost (PhP) | Gross Margin (PhP) | ROI (%) |
|---|---|---|---|---|---|
| $T_1$ | 4.22 | 50,619.05 | 41,700.00 | 8,919.05 | 21.39 |
| $T_2$ | 6.77 | 81,200.00 | 52,427.50 | 28,772.50 | 54.88 |
| $T_3$ | 8.00 | 95,980.95 | 47,950.00 | 48,030.95 | 100.17 |
| $T_4$ | 7.10 | 85,228.57 | 46,312.50 | 38,916.07 | 84.03 |
| $T_5$ | 7.46 | 89,542.86 | 45,250.00 | 44,292.86 | 97.88 |
| $T_6$ | 8.95 | 107,390.48 | 44,062.50 | 63,327.98 | 143.72 |

Legend:
$T_1$ – Control (No fertilizer)
$T_2$ – 120-40-45 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$ (Recommended Rate [RR])
$T_3$ – 5 t $ha^{-1}$ Poultry litter (PL)
$T_4$ – 1.25 t $ha^{-1}$ PL + 90-30-33.75 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$
$T_5$ – 2.5 t $ha^{-1}$ PL + 60-20-22.5 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$
$T_6$ – 3.75 t $ha^{-1}$ PL + 30-10-11.25 kg N, $P_2O_5$, $K_2O$ $ha^{-1}$

## 4. Conclusion

The combined application of poultry litter and inorganic fertilizer significantly increased plant height, culm length, and diameter of sweet sorghum. Similarly, the application of poultry litter + inorganic fertilizer significantly increased the panicle length, panicle fresh and dry weight, and grain yield while the combination of 3.75 t $ha^{-1}$ PL + 30-10-11.25 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$ inorganic ($T_6$) gave the highest grain yield. The other combination of poultry litter + inorganic fertilizer gave a comparable grain yield with $T_{6.}$ Therefore, growing sweet sorghum was highly profitable when applied with a combination of poultry litter and inorganic fertilizer at the rate of 3.75 t $ha^{-1}$ 30-10-11.25 kg $ha^{-1}$ N, $P_2O_5$, $K_2O$.

**Acknowledgment**

The author would like to thank the following persons who made this work possible. To Prof. Ed Allan L. Alcober, his thesis adviser for his helpful comments and strong participation in the learning process of this research. To. Dr. Dionesio M. Baňoc for his unwavering support and assistance in motivating and encouraging him to conduct this research undertaking.

**Declaration**

I hereby declare that this research paper entitled **"**Response of Sweet Sorghum (*Sorghum bicolor* l. Moench) to the Combined Application of Poultry Litter and Inorganic Fertilizer" was not submitted in any other refereed journals. I hereby declare also that the data in the submitted paper is original.

**Authors' Contributions**

*All authors contributed to this research.*

**Funding**

*There is no funding for this research.*

**Institutional Review Board Statement**

*All Institutional Review Board Statements are confirmed and approved.*

**Data Availability Statement**

*Data presented in this study are available at fair request from the respective author.*

**Ethics Approval and Consent to Participate**

*This work carried out at Provincial Agriculturist Office and department of Agronomy and followed all the department instructions.*

**Consent for Publication**

*Not applicable.*

**Conflicts of Interest**

*The authors declare no conflict of interest.*

## 5. References

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