Effects of manure types on the growth and yield of sweet sorghum (*Sorghum bicolor* L.) in dryland

**Samanhudi¹, P Harsono², E Handayanta³, R Hartanto⁴, A Yunus⁵ and K Prabawati⁵**

¹ Study Program of Agrotechnology, Faculty of Agriculture, Universitas Sebelas Maret, and Center for Research and Development of Biotechnology and Biodiversity, LPPM Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Surakarta, 57126, Indonesia
² Study Program of Agrotechnology, Faculty of Agriculture, Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Surakarta, 57126, Indonesia
³ Study Program of Animal Science, Faculty of Agriculture, Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Surakarta, 57126, Indonesia
⁴ Study Program of Food Science and Technology, Faculty of Agriculture, Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Surakarta, 57126, Indonesia
⁵ Student of Faculty of Agriculture, Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Surakarta, 57126, Indonesia

E-mail: samanhudi@staff.uns.ac.id

**Abstract.** Sweet sorghum is one of the superior commodities to increase the production of food and energy. Sweet sorghum seeds produce carbohydrates that can be processed into food ingredients, while the sap from the stems and starch in the seeds can be converted into bioethanol through fermentation processes. Sweet sorghum crops tolerant to drought and stagnant water can produce on marginal land and relatively resistant to pests and diseases. This research aims to determine the interaction between sweet sorghum varieties and kinds of organic fertilizer on the growth and yield of sweet sorghum in dryland. The research method is a factorial experiment using Randomized Completely Block Design (RCBD), which consists of two factors, which is sweet sorghum varieties and manure types. The varieties which were used are Kawali and Numbu. The second treatment used is without manure, chicken manure, goat manure, cow manure, and vermicompost. The total treatment combination is ten units, and each combination is repeated three times. The research variables are plant height, stem diameter, leaf area index, fresh stover weight, dry stover weight, sap content, panicle length, number of seeds per panicle, and production per hecrtare. Data were analyzed using the F test with a 95% confidence level if there is significantly a difference and then followed by the DMRT method at the 5% level. This research shows that the highest production per hecrtare is sorghum treatments by chicken manure equal 2.64 ton/ha, and this yield is higher than all other treatments.

1. **Introduction**

   Sweet sorghum (*Sorghum bicolor* (L.) Moench) is a food crop (grain), but apart from being used as the food, it is also used as animal feed and bioethanol. The utilization of sweet sorghum is generally obtained from the main products (stems and seeds) and waste (leaves), and by-products (dregs/bagasse) [1]. The productivity of bioethanol sorghum 6,000 l/ha/year comes from stems and 2,000 l/ha/year from sorghum...
seeds, higher than sugarcane 5.025 l/ha/year, corn 3.461 l/ha/year, beet sugar 6.679 l/ha/year and cassava 4.500 l/ha/year. As a bioenergy raw material, sorghum fulfills the three main requirements needed to be mass-produced into biofuels, namely not competing with food crops, high productivity, and low production costs [2].

Sorghum is the fifth important cereal crop globally after wheat, rice, maize and barley [3, 4]. Sorghum is a multifunctional plant and zero waste because all parts of the plant can be used for food, feed, and industrial purposes [4]. Sorghum can be grown in tropical, subtropical areas and belongs to the C4 group, such as corn and sugarcane, which is efficient in carrying out photosynthesis, especially in high temperatures and lack of water. Sweet sorghum requires one-third or less of the water needed by sugarcane and maize to grow well in various climates, including tropical, subtropical, and dry regions.

The important advantage of sorghum from the cultivation aspect is its wide adaptability to drought conditions. It has a competitive advantage compared to other commodities developed in dryland in Indonesia [5]. Sufficient groundwater or rainfall and timely planting allow for the profitable growth of upland sorghum yields [6].

Efforts to realize the availability of food with sufficient human funds for the community through intensification of plant cultivation to obtain high yields can negatively impact. The application of technology, soil management, and less precise plants and tend to be overexploited can reduce physical, chemical and biological soil fertility [7]. The application of fertilizers and pesticides that exceeds the dosage to maintain and increase crop yields causes the concentration of several types of heavy metals in soil, water, and plants to grow beyond the permissible threshold [8]. It is necessary to study the genotype of sweet sorghum through plant breeding programs, adapting well to these dryland conditions [9].

The availability of nutrients that plants can absorb is one of the factors that influence production. Balanced availability as needed by plants will produce optimum growth. Types of manure include cow, chicken, goat, and vermicompost manure. Naturally, mature manure has been widely used in the cultivation of various horticultural crops. It is known as an organic material used to improve soil physical, chemical, and biological properties [10]. Besides, manure causes humus to form, thereby increasing the root power of water, making it easier for plant roots to absorb nutrients for plant growth and development [11].

Manure contains many organic materials that can improve damaged soil conditions into fertile and have a diversity of soil microorganisms [12]. This fertilizer helps improve soil structure by improving organic matter and soil ability in maintaining groundwater [13]. Organic fertilizers, as providers of macro and micronutrients [14], enhance the volume of plant roots [15] and increase the value of pH and organic materials of soil [16, 17, 18].

This study aims to determine the interaction between varieties of sweet sorghum and kinds of manure on the growth and yield of sweet sorghum in dryland, to obtain the right type of manure to increase the growth and yield of sweet sorghum in dryland, and to get the appropriate varieties of sweet sorghum for cultivated well in dryland.

2. Methods

The research materials used included: sweet sorghum seeds of Numbu and Kawali varieties, chicken manure (20 tons/ha), goat manure (20 tons/ha), cow manure (20 tons/ha), and vermicompost fertilizer (20 tons/ha). The research tools used include soil cultivation, planting, maintenance, observation, equipment for soil analysis, and stationery.

This research was conducted on dryland using a Randomized Completely Block Design (RCBD), consisting of two treatment factors. The first factor was sweet sorghum varieties. The second factor was the type of manure. The factor I: varieties, consisting of two levels, namely Numbu variety and Kawali variety. Factor II: kinds of manure, composed of five levels, namely without manure, chicken manure, goat manure, cow manure, and vermicompost fertilizer, so that ten treatment combinations will be obtained and each treatment combination is repeated three times with a total of 30 experimental units.
The observation variables included plant height, stem diameter, leaf area index, fresh stover weight, dry stover weight, sap content, panicle length, number of seeds per panicle, and production per hectare. The data were analyzed with variance using the F test with a confidence level of 95%. If there is a significant difference, then proceed with the Duncan Multiple Range Test (DMRT) with a level of 5%.

### 3. Results and discussion

#### 3.1. Plant height

Plant height is a plant size that is often observed both as an indicator of growth and a parameter used to measure environmental influences or the treatment applied. Plant height is the most accessible measure of growth [19].

The results of the analysis of variance showed that the manure treatment had a significant effect on the height of sweet sorghum (table 1). In contrast, the sweet sorghum variety had no significant effect on plant height, and there was no interaction between varieties and types of manure.

| Varieties | Manure types | Average |
|-----------|--------------|---------|
| Numbu     | Without manure | 146.17  |
|           | Chicken      | 187.35  |
|           | Goat         | 156.43  |
|           | Cow          | 142.80  |
|           | Vermicompost | 150.25  |
|           | Average      | 156.60 a|
| Kawali    | Without manure | 160.40  |
|           | Chicken      | 198.48  |
|           | Goat         | 160.05  |
|           | Cow          | 150.00  |
|           | Vermicompost | 146.80  |
|           | Average      | 163.12 a|

Note: The numbers followed by the same letter are not significantly different in the Duncan test at the 5% level.

Table 1 shows that the application of chicken manure gave the highest yield with an average of 192.92 cm, while the lowest plant height was treated with cow manure, namely 146.40 cm. However, it was not significantly different from the treatment of goat manure and vermicompost fertilizer. In both the Numbu and Kawali varieties, chicken manure's application produced the highest growth compared to other manure. The Numbu variety made a plant height of 187.35 cm, while the lowest was in the cow manure treatment, namely 142.80 cm. In the Kawali variety, giving chicken manure also produced the highest growth, namely 198.48 cm, while vermicompost fertilizer treatment showed the lowest yield, namely 146.80 cm.

Chicken manure produces the best growth among other manure because metabolic processes greatly influence plant height in the plant body itself. Plants can carry out plant metabolic activities requiring nutrients obtained from fertilization either through planting media soil. The chicken manure application can increase the nutrients N, P, and K in the soil needed for growth. According to the opinion [20], plants will grow well and fertile if plants' nutrients are available in sufficient quantities.

#### 3.2. Stem diameter

The growth of a plant can be identified by cell extension and enlargement. One of the parameters to determine this is to know the diameter of the stem. Plants that have a larger stem diameter are likely to grow better. The stem's diameter is more significant (table 2), so it can support the plant more strongly, so it doesn't collapse easily. [21] stated that for plants to carry out their physiological functions properly, their stems must be able to stand upright.

| Varieties | Manure types | Average |
|-----------|--------------|---------|
| Numbu     | Without manure | 1.35    |
|           | Chicken      | 1.37    |
|           | Goat         | 1.24    |
|           | Cow          | 1.31    |
|           | Vermicompost | 1.36    |
|           | Average      | 1.31 a  |
| Kawali    | Without manure | 1.23    |
|           | Chicken      | 1.51    |
|           | Goat         | 1.33    |
|           | Cow          | 1.23    |
|           | Vermicompost | 1.45    |
|           | Average      | 1.35 a  |

Note: The numbers followed by the same letter are not significantly different in the Duncan test at the 5% level.
Based on table 2 above, the type of manure affects the two varieties' stem diameter (Kawali and Numbu). However, the planting area classification does not affect stem diameter. The largest stem diameter was shown in the chicken manure treatment with an average of 1.44 cm, although it was not different from the vermicompost fertilizer treatment. Simultaneously, the smallest diameter was shown in cow manure treatment with an average of 1.27 cm, which was not significantly different from goat manure treatment and treatment without fertilizer.

The results of the analysis of variance showed that the treatment of the type of fertilizer had a very significant effect on the stem diameter so that if various kinds of fertilizers were given, the plant stem diameter would be different. The treatment of various varieties did not affect the stem diameter. It is presumably because these two varieties have almost the same plant morphology not to show any differences. There was an interaction between types of fertilizers and varieties, which showed a significant difference. It means that certain varieties will affect when given certain fertilizers. The treatment of chicken manure on the Numbu variety had the largest stem diameter. The diameter of the sweet sorghum stems increases with age. The size of the stem diameter decreases as it enters the generative phase. It is thought to result from photosynthesis being widely distributed for the formation of seeds.

Chicken manure shows a larger stem diameter due to chicken manure, which contains more nutrients than other manure. The application of organic fertilizers can increase the rate of plant growth. Without manure, the plants are stunted, characterized by small leaves and small diameter of plant stems and short plants and low yields.

3.3. Leaf area index
Leaves are generally seen as the main photosynthate-producing organ. Leaf observations are indispensable apart from being a growth indicator and supporting data to explain the growth processes that occur, such as in the formation of plant biomass [19]. N supply increases chlorophyll content, total protein, sugar content, protein, fat, auxin formation stimulant to soften the cell walls, improve plant's ability in absorbing water, and metabolites associated with photosynthesis [22, 23, 24, 25].

Leaves are the photosynthetic organs of plants, so the leaf area reflected by the leaf area index is important to note. Leaf area index is the net result of assimilation of the unity of leaf area and time. Leaf area is not constant with time but decreases with increasing plant age (table 3). Leaf area index is a description of the leaf surface ratio to the land area occupied by plants. The plant growth rate is influenced by the net assimilation rate and leaf area index. A high net assimilation rate and optimum leaf area index will increase plant growth rate [26].

| Varieties | Without manure | Chicken | Goat | Cow | Vermicompost | Average |
|-----------|----------------|---------|------|-----|--------------|---------|
| Numbu     | 4.35           | 7.60    | 4.60 | 4.91| 4.67         | 5.23 a  |
| Kawali    | 4.34           | 6.86    | 4.76 | 6.03| 4.67         | 5.33 a  |
| Average   | 4.35 a         | 7.23 c  | 4.68 a| 5.47 b| 4.67 a       | 5.28    |

Note: The numbers followed by the same letter are not significantly different in the Duncan test at the 5% level.

Table 3 shows that the application of various kinds of manure, namely chicken manure, goat manure, cow manure, and vermicompost fertilizer, significantly affects the leaf area index of the two sweet sorghum varieties. It means that the types of manure given to sweet sorghum plantations will have different effects on the plant's leaf area index. However, the treatment of goat and vermicompost manure is not different from the treatment without fertilizer. It is presumably because the results of soil chemical analysis show that the organic matter on the experimental land is moderate so that with the addition of manure, which has not too much nutrient content, the addition of these fertilizers does not have an effect on leaf growth in the two sweet sorghum varieties. Table 3 also shows that the grouping of plants into three groups significantly affects the leaf area index. It is possible because the sunlight absorbed by plants differs based on the rays' location and direction.
Spacing is one factor that influences the leaf area index. The spacing on sorghum fields is wide enough (70 cm x 10 cm) to allow the leaves not to shade each other. The leaves receive the closer to the soil surface, the less light. It is a result of the blackout carried out by the upper layer of leaves. Suppose the lower canopy layer receives light below the light compensation point. In that case, these leaves will be parasitic to the plant itself because the carbohydrates produced are smaller than those used for leaf maintenance [19].

The highest average leaf area index was 7.23 in the chicken manure treatment (table 3). [27] showed that the leaf area index of maize is more significant than 3.0, so 95% of sunlight is absorbed. Leaf area reflects photosynthesis, while leaf area index reflects the amount of light interception by plants. Although the stem also intercepts light, it is more effective in the leaves. Leaf area index increases with increasing light intensity until the optimum limit of plant intercept light. The greater photosynthesis, the greater assimilation produced. The assimilation is a supporter of leaf area growth. The number of leaves is also closely related to the amount leaf area index of the plant.

### 3.4. Fresh stover weight

Fresh stover weight is influenced by plant height and the number of leaves (table 4): the more leaves and the taller the cajanus plant, the greater the fresh stover weight. According to [28], fresh canopy weight was influenced by water uptake by plants. Water that plants absorb is a medium for the entry of nutrient elements into plants used for their growth. Water that plants absorb is also stored in vacuoles.

**Table 4. Effect of manure types on fresh stover weight of two varieties of sweet sorghum.**

| Varieties | Without manure | Chicken | Goat | Cow | Vermicompost | Average |
|-----------|----------------|---------|------|-----|--------------|---------|
| Numbu     | 483.72         | 620.51  | 447.75 | 490.12 | 519.91       | 512.40 a |
| Kawali    | 504.43         | 609.31  | 505.50 | 429.86 | 536.66       | 517.15 a |
| Average   | 494.08 a       | 614.91 b| 476.63 a| 459.99 a| 528.29 ab    | 514.78  |

Note: The numbers followed by the same letter are not significantly different in the Duncan test at the 5% level.

The weight of fresh stover is an indicator that shows the rate of water and nutrient uptake by plants for metabolism. As stated by [29], the weight of fresh stover is almost entirely due to the plants’ water uptake. The effectiveness of water absorption by plants and its role in plant growth and development is reflected in the fresh stover weight.

Table 4 shows the difference in weight of fresh stover for each type of fertilizer for each variety and gives a significant effect, while varieties and interactions between types of organic fertilizers and varieties also do not have a significant impact on the fresh stover weight of sweet sorghum. The difference in fresh stover weight was seen significantly higher in chicken manure and vermicompost treatment, namely 614.91 g and 528.29 g, respectively, and this yield is higher than all other treatments.

According to [30], physiologically fresh weight usually consists of two ingredients: water and carbohydrates. Water is the main component in green plants, 70-90% of the plant’s fresh weight [28]. Thus, the higher the soil’s nutrients, the more excellent carbohydrates produced from the photosynthesis process.

### 3.5. Dry stover weight

The weight of dry stover can be used as a reference for measuring the growth of a plant. The fresh stover weight can change in a relatively short time due to loss of plant moisture content [28]. Also, dry stover weight accumulates various food reserves, including protein, carbohydrates, and fats. The greater the dry plant weight, the plant’s metabolic process runs well, and vice versa. If the dry plant weight is getting smaller, its metabolic process is not running well or hampered.

The dry stover weight is the organic material found in the form of biomass. It is a reflection of the capture of energy by plants in the photosynthetic process. The higher dry stover weight indicates that the photosynthesis process is running well (table 5).
Table 5. Effect of manure types on dry stover weight of two varieties of sweet sorghum.

| Varieties | Without manure | Chicken | Goat | Cow | Vermicompost | Average |
|-----------|----------------|---------|------|-----|---------------|---------|
| Numbu     | 100.73         | 114.87  | 82.30| 108.66| 108.83        | 103.08 a|
| Kawali    | 53.89          | 117.34  | 75.02| 88.21| 84.84         | 83.86 a |
| Average   | 77.31 a        | 116.11 b| 78.66 a| 98.44 ab| 96.84 ab     | 93.47   |

Note: The numbers followed by the same letter are not significantly different in the Duncan test at the 5% level.

Table 5 shows that the highest weight of dry stover in the chicken manure treatment is 116.11 g, but it is not different from cow manure and vermicompost treatment. The results of variance analysis showed no interaction between the use of organic fertilizers on the volume of plant roots in various sweet sorghum varieties.

Treatment of varieties showed significant differences in the weight of dry stover. Where the Numbu variety weighs more when compared to the Kawali variety. However, in the treatment of chicken manure, the difference between the two varieties was not significant. It is presumably because chicken manure has a high N content among other manure so that the two varieties can maximize growth where N functions for leaf growth. The leaves are where the photosynthesis process takes place, producing a lot of carbohydrates so that the plant weighs more.

Ninety percent of dry plant weight is the result of photosynthesis. With the inhibition of the photosynthesis process, the dry plant weight will be low. It is suspected that the energy produced is only used by plants to meet their power needs to grow normally because plants grow under environmental pressure, so that storage in the form of dry matter is minimal [28].

Apart from environmental factors, the balance factor between CO\textsubscript{2} uptake (photosynthesis) and CO\textsubscript{2} release (respiration) also plays a role in the size of the dry stover weight. Dry plant weight is a balance between taking CO\textsubscript{2} from the photosynthesis process and removing CO\textsubscript{2} from the respiration process. If the respiration is greater than the plant photosynthesis, the dry plant weight will decrease [26].

3.6. The content of the sap
Sorghum sap is a fluid obtained from pressing sweet sorghum stems, which have a brownish-green color. Apart from containing sugar, sorghum sap also contains other substances (non-sugar substances) such as water, fibers, organic and inorganic substances. Sorghum sap from sorghum stems can be used to manufacture ethanol because the composition of sorghum sap is almost the same as sugarcane sap [31]. Effect of manure types on the content of sap of two varieties of sweet sorghum can be seen in the table 6.

Table 6. Effect of manure types on the content of sap of two varieties of sweet sorghum.

| Varieties | Without manure | Chicken | Goat | Cow | Vermicompost | Average |
|-----------|----------------|---------|------|-----|---------------|---------|
| Numbu     | 80.80          | 87.73   | 67.33| 77.67| 78.67         | 78.44 a |
| Kawali    | 83.33          | 102.67  | 74.67| 66.27| 80.27         | 81.44 a |
| Average   | 82.07 ab       | 95.20 b | 71.00 a| 71.97 a| 79.47 ab      | 79.94   |

Note: The numbers followed by the same letter are not significantly different in the Duncan test at the 5% level.

The use of manure had a significant effect on the content of sweet sorghum sap, but the respective sweet sorghum varieties had no significant impact. Also, there was no interaction between organic fertilizers and the sap content of the two sweet sorghum varieties. Table 6 shows that cow manure and goat manure treatment is not different, as is the treatment of vermicompost manure with no fertilizer treatment.

The highest content of sap was in the Kawali variety with 102.67 ml of chicken manure, and the lowest was in the treatment of cow fertilizer, which was 66.27 ml. Whereas in the Numbu variety, the highest sap content was seen in chicken manure treatment, as much as 87.73 ml, and the lowest sap
content in goat manure treatment was 67.33 ml. The content of the sap is closely related to the stem diameter. The larger the stem diameter, the more sap is contained. The difference in sap content is caused by differences in stem size and the amount of sap produced by each variety.

3.7. Panicle length
The estimation of phenotypic variety, environmental variety, and genetic variety shows that the height of the plant, the number of leaves, and the number of seeds per panicle, the environmental influence is still relatively large on the diversity of these characters. In contrast, the weight of biomass, panicle length, and weight of seeds per panicle is a more dominant control for these characters, as indicated by a high broad-sense heritability value of more than 90% [32].

The variance results showed that Numbu and Kawali varieties' use did not affect the panicle length observation variable. The interaction between organic fertilizers and varieties did not give any interaction on panicle length. The average panicle length due to the treatment of varieties for each type of manure on sweet sorghum is presented in table 7 below.

Table 7. Effect of manure types on panicle length of two varieties of sweet sorghum.

| Varieties | Without manure | Chicken | Goat | Cow | Vermicompost | Average |
|-----------|----------------|---------|------|-----|--------------|---------|
| Numbu     | 17.47          | 17.60   | 15.87| 16.47| 17.33        | 16.95 a |
| Kawali    | 16.33          | 17.87   | 17.20| 15.80| 16.93        | 16.83 a |
| Average   | 16.90 abc      | 17.74 c | 16.54 ab | 16.14 a | 17.13 bc | 16.89   |

Note: The numbers followed by the same letter are not significantly different in the Duncan test at the 5% level.

Table 7 shows that the type of manure treatment has a significant effect on panicle length, and plant grouping also significantly impacts. The treatment of giving various kinds of manure to the provision of chicken manure gave the highest average panicle length of 17.87 cm in the Kawali variety. The lowest was the treatment of cow manure. It is presumably because chicken manure has a higher nutrient content compared to other types of fertilizers.

In the Numbu variety, the highest panicle length was also shown in the chicken coop treatment, although it was not much different from the without manure treatment, namely 17.60 cm and 17.47 cm. The plant's need for nutrients is sufficiently fulfilled so that sweet sorghum plants can produce longer panicles. The increase in panicle length is closely related to the increase in weight of dry stover.

3.8. Number of seeds per panicle
Seeds are a food reserve and can be used as seeds that can be used as planting material for the following season. The factor determining seed quality is the amount of carbohydrate substrate available for metabolism that supports early plant growth. Forming seeds in various plants is not the same, either due to environmental factors or genetic factors. Imperfections in the fertilization process of an ovule will cause unequal seeds to form [33].

Table 8. Effect of manure types on the number of seeds per panicle of two varieties of sweet sorghum.

| Varieties | Without manure | Chicken | Goat | Cow | Vermicompost | Average |
|-----------|----------------|---------|------|-----|--------------|---------|
| Numbu     | 1.444          | 2.956   | 1.982| 1.998| 2.243        | 2.125 a |
| Kawali    | 1.575          | 2.478   | 1.561| 2.131| 1.778        | 1.905 a |
| Average   | 1.509 a        | 2.717 c | 1.771 ab | 2.065 b | 2.011 b | 2.015   |

Note: The numbers followed by the same letter are not significantly different in the Duncan test at the 5% level.

Based on table 7, it can be seen that the chicken manure treatment produced a higher number of seeds per panicle compared to other fertilizer treatments. The treatments without fertilizers, cow manure, goat manure, and vermicompost fertilizer were not significantly different. Although it was not significantly different, cow manure produced many seeds per panicle from other fertilizers that had no significant
effect, namely an average of 2.065 seeds. The variation in sorghum yield is related to variations in the number of seeds. A large number of seeds is essential for high yields and is dependent on adequate plant development until flowering [34].

The Numbu variety had the highest number of seeds per panicle, namely 2.956 seeds in the chicken manure treatment and the lowest in the without fertilizer treatment, namely 1.444 seeds. In the Kawali variety, the highest number of seeds per panicle was in the chicken treatment. The lowest was in the goat manure treatment, which was only 1.561 seeds less than the treatment without fertilizer 1.575 seeds. The type of variety used did not affect the number of seeds per plant. There was no significant interaction between the types of manure and the number of seeds per panicle in the two varieties. This is presumably because these two varieties have almost the same age of growth and flowering, so that the two varieties do not have a significant difference. The addition of fertilizers given to the two varieties finally showed no interaction.

According to [35], that the decomposition process of organic matter will release some nutrients such as N, P, and K. Based on this opinion, organic N, P, and K fertilization is very necessary for plants, the process of plant photosynthesis, the process of photosynthesis will produce photosynthate and part of the photosynthetic product will be used for filling seeds.

3.9. Production per hectare
Production is a process of transformation (changing) from inputs (factors of production) to outputs (products) that are ready to be traded. In farming activities, production and productivity cannot be separated. [36] stated that the soil's condition and fertility determined production and productivity per hectare, the varieties planted, the fertilizers used, both the type and the dosage. The measure of the success of a farm is the productivity of the farm itself.

The variance analysis showed that the interaction between fertilizer and sweet sorghum varieties occurred and had a significant effect. If the Kawali or Numbu varieties' sorghum is given different manure, the yield will be different. Treatment of various varieties did not affect the amount of crop production per hectare. Plant grouping based on a land slope also does not affect yield per hectare of the plant.

According to [37], one of the factors that mediate production is biological factors such as; agricultural land with various fertility levels, seeds, varieties, fertilizers, pesticides, weeds, etc. In the experiment, the pilot plot was divided into three fertility levels, using two varieties, which in table 9 shows that the treatment of varieties did not affect. Still, the treatment of various kinds of manure had a very significant effect on yield per hectare. The level of soil fertility can be seen in the land slope. Land that has a high slope has more nutrient content, and this is analogous to water flow. Variety does not affect because the two varieties have similar morphology, so that the different varieties used do not affect.

**Table 9. Effect of manure types on production per hectare of two varieties of sweet sorghum.**

| Varieties | Without manure | Chicken | Goat | Cow | Vermicompost | Average |
|-----------|----------------|---------|------|-----|--------------|---------|
| Numbu     | 1.75           | 2.78    | 1.54 | 1.75| 1.92         | 1.95 a  |
| Kawali    | 1.79           | 2.50    | 1.97 | 2.06| 1.84         | 2.03 a  |
| Average   | 1.77 a         | 2.64 b  | 1.76 a| 1.91 a| 1.88 a       | 1.99    |

Note: The numbers followed by the same letter are not significantly different in the Duncan test at the 5% level.

Manure treatment has a very significant effect, which is seen in the table above. The use of chicken manure gives the best production results, which is 2.64 tons/ha, which is significantly different from the treatment of other organic fertilizers. The use of goat, cow, vermicompost manure and no fertilizer did not make a difference to the plant's yield per hectare.
The use of chicken manure tended to show the highest production per ha of 2.78 tons/ha for the Numbu variety and 2.50 tons/ha for the Kawali variety. The content of N, P, and K in chicken manure tends to be higher than the N, P, and K content of cow manure, vermicompost manure, and goat manure. Increased yield per hectare can occur due to increased nutrients and climatic factors that support plant growth during the generative period. In this generative phase, plants require more water and available nutrients, and all photosynthate products are transferred to seed formation. In experiments conducted, plants in the generative phase lack water because it has entered the dry season at the beginning of the flowering phase. The plant's metabolic process is slightly hampered. Sorghum requires less water for growth than some other cereal crops. The demand for water increases with the sorghum plant's growth, reaching its peak during the flowering period. The average water requirement for growing sorghum is 200-300 mm, far below that of maize, which requires 500-600 mm of water on average for optimal production processes [38].

The yield potential of the Numbu variety was 3.11 tons/ha, and the Kawali variety was 2.96 tons/ha. Not only water availability, but another thing that is thought to make the yield per ha far below the yield potential of the two varieties is nutrient availability. The addition of organic fertilizers to the experimental land was deemed insufficient to meet the plant's nutritional needs. According to [34], nitrogen fertilizer is needed for the growth and yield of sorghum at a dose of 90 kg/ha, P₂O₅ as much as 45 kg/ha, and 25 kg/ha K₂O so that the addition of nutrients is needed when the plant enters the flowering phase.

4. Conclusion
The two varieties of sorghum, namely the Numbu and Kawali varieties, showed good results and could be planted on drylands. It was based on good plant appearance and good enough yields. Almost all of the manure used affected the observed variables. The type of manure that shows the best results is the type of chicken manure. Seen in the average value of all observed variables. Chicken manure is the right fertilizer for use on dryland. This research shows that the highest production per hectare is sorghum treatments by chicken manure equal 2.64 tons/ha and this yield is higher than all other treatments.

Acknowledgment
The author would like to thank the Research and Community Service Institute of Universitas Sebelas Maret for funding this research through the Mandatory Research scheme for PNBP funds for the 2020 fiscal year.

References
[1] Sumantri A, Hanyokrowati and B Guritno 1996 Prospek pengembangan sorgum manis untuk menunjang pembangunan agroindustri di lahan kering (Malang: Makalah dalam Lokakarya Nasional Pertanian Lahan Kering Beberapa Kawasan Pembangunan Ekonomi Terpadu di Kawasan Timur Indonesia)
[2] Medco Energy 2007 Kesimpulan notuland pada workshop Peluang dan Tamangan Sorgum Manis sebagai Bahan Baku Bioetanol (Jakarta:Dirjen Perkebunan, Departemen Pertanian)
[3] Talanca A H and Andayani N N 2015 Perkembangan Perakitan Varietas Sorgum Di Indonesia (Indonesia:Balai Penelitian Tanaman Serealita)
[4] Suarni S 2016 Peranan sifat fisikokimia sorgum dalam diversifikasi pangan dan industri serta prospek pengembangannya J. Lit. Pert. 35 99-110
[5] Siparida M P 2003 Prospek pengembangan sorghum di Indonesia sebagai komoditas alternatif untuk pangan, pakan, dan industry J. Lit. Pert. 22 (4) 133-140
[6] Bandarun V, Stewart B A, Baumhardt R L, Ambati S, Robinson C A and Schlegel A 2006 Growing dryland grain sorghum in clumps to reduce vegetative growth and increase yield J. Agronomy 98 1109-1120
[7] Wahyunto and Dariah A 2014 Degradasi lahan di Indonesia: kondisi existing, karakteristik, dan penyeragaman definisi mendukung gerakan menuju satu peta J. Sumberdaya Lahan 8 (2) 81-93
[8] Sutrisno dan Kuntyastuti H 2015 Pengelolaan cemaran kadmium pada lahan pertanian di Indonesia Bulletin Palawija 13(1) 83-91
[9] Soeranto 2010 Sorgum sebagai bahan baku bioethanol http://www.batan.go.id diakses 20 November 2011
[10] Siregar M E 1991 Kebutuhan pupuk untuk pengembangan tanaman pakan ternak Proc. Nasional Efisiensi Penggunaan Pupuk V (Bogor:Puslitakan)
[11] Sutedjo M M 2002 Pupuk dan Cara Pemupukan (Jakarta:Rineka Cipta)
[12] Samanhudi, Yunus A, Pujiasmanto B, Cahyani V R and Lestariana D S 2017 The effect of arbuscular mycorrhiza and organic manure on soybean growth and nutrient content in Indonesia Bulgarian Journal of Agricultural Science 23(4) 596–603
[13] Nugroho P A, Widyastuti Y, Samanhudi and Yunus A 2017 Growth response of artemisia annua by effect of types and composition of organic fertilizer in lowland J. of Agricultural Science and Technology B 7(5) 339–345
[14] Samanhudi, Yunus A and Pujiasmanto B 2018 Budidaya organik kunyit pada cluster biofarmaka kabupaten Karanganyar Caraka Tani: Journal of Sustainable Agriculture 33(1) 34–41
[15] Prasetyo L, Widyastuti Y, Yunus A and Samanhudi 2018 The growth response of Artemisia annua L. to organic fertilizer type in lowland IOP Conference Series: Earth and Environmental Science 142(1)
[16] Muktiyanta M N A, Samanhudi, Yunus A, Pujiasmanto B and S Minardi 2018 Effectiveness of cow manure and mycorrhiza on the growth of soybean IOP Conference Series: Earth and Environmental Science 142(1)
[17] Samanhudi, Pujiasmanto B, Yunus A, Supyani, Suntoro, Widiijanto H and Prabowo S M 2017 The effect of manure and mycorrhiza application to the soil microbes biodiversity in terms of increasing soybean yield in marginal land in Indonesia Bulgarian Journal of Agricultural Science 23(6) 994–1003
[18] Samanhudi, Sudadi, Yunus A, Pujiasmanto B and Mahasti W 2017 Pengaruh kascing dan mikoriza terhadap pertumbuhan dan hasil Tribulus terrestris Jurnal Agrotek Indonesia 2(1) 1-6
[19] Sitompul M dan Guritno B 1995 Analisis Pertumbuhan Tanaman (Yogyakarta: Gadjah Mada University Press)
[20] Dwidiyoseputro D 1994 Pengantar Fisiologi Tumbuhan (Jakarta: Gramedia Pustaka Utama)
[21] Islami T dan Utomo W H 1995 Hubungan Tanah, Air dan Tanaman (Semarang: IKIP Semarang Press)
[22] Dawiyah R Y A, Yunus A, Samanhudi, Widyastuti Y and Widodo H 2018 Shading and vermicompost effect on growth and flavonoid content of tapak liman (Elephantopus scaber L.) IOP Conference Series: Earth and Environmental Science 142(1)
[23] Permana H H, Widyastuti Y, Samanhudi and Yunus A 2018 Response of Artemisia annua L. to shade and manure fertilizer application in lowland altitude IOP Conference Series: Earth and Environmental Science 142(1)
[24] Riyana D, Widyastuti Y, Widodo H, Purwanto E and Samanhudi 2018 Effect of manure and plants spacing on yield and flavonoid content of Elephantopus scaber L. IOP Conference Series: Earth and Environmental Science 142(1)
[25] Yunus A, Samanhudi, Brahamanto N and Widyastuti Y 2018 Artemisia annua respon to various types of organic fertilizer and dose in lowland IOP Conference Series: Earth and Environmental Science 142(1)
[26] Gardner F P, Pearce R B dan Mitchell R L 1991 Fisiologi Tanaman Budidaya Penerjemah: H Susilo (Jakarta: Universitas Indonesia Press)
[27] Rohrig M, Stutzel H and Alt C 1999 A three- dimensional approach to modeling light interception in heterogeneous canopies Agronomy Journal 91(6) 1024-1032
[28] Fitter A H dan Hay R K M 1994 Fisiologi Lingkungan Tanaman Penerjemah: Andani S dan Purbayanti E D (Yogyakarta: Gadjah Mada University Press)
[29] Prawiranata W, Harran S dan Tjondronegoro 1981 *Dasar dalam Fisiologi Tumbuhan* Jilid II (Bogor: Departemen Agronomi Fakultas Pertanian IPB) p 313

[30] Wijayanti Y R 2007 Substitusi Tepung Gandum (*Triticum aestivum*) Dengan Tepung Garut (*Maranta arundinacea* L) Pada Pembuatan Roti Tawar *Skripsi* (Yogyakarta: Fakultas Pertanian Universitas Gadjah Mada)

[31] Ratna P P S 2006 Kajian pengaruh fouling pada pemurnian nira tebu *J. Teknik Kimia* 1(1) (Surabaya: UPN Veteran)

[32] Sungkono, Trikoesoemaningtyas, Wirmas D, Sopandie D, Human S dan Yudiarto M A 2009 Pendugaan parameter genetik dan seleksi galur mutan sorgum (*Sorghum bicolor* L. Moench) di tanah masam *J. Agron. Indonesia* 37(3) 220-225

[33] Sutopo L 2002 *Teknologi Benih* (Jakarta: Rajawali Press)

[34] Tohari Y 2009 *Kandungan hara pupuk kandang* http://tohariyusuf.wordpress.com/2009/04/25/kandungan-hara-pupukkandang/ Diakses pada 29 Februari 2012

[35] Priyadi R, Juhaeni A H dan Taufiq H 2020 Pengaruh kombinasi porasi dan pupuk hayati (M-Bio) terhadap pertumbuhan dan hasil tanaman cabai rawit (*Capsicum frustescens* L.) varietas *Bara Agricola* 10(2) 74-84

[36] Partadiredja A 1980 *Beberapa Masalah Dalam Produksi Pangan* (Jakarta: Prisma)

[37] Soekartawi 1990 *Teori Ekonomi Produksi dengan Pokok Bahasan Analisis Fungsi Cobb-Douglas* (Jakarta: Rajawali Press)

[38] House L R 1985 *A Guide to Sorghum Breeding* *International Crops Research Institute for the Semi-Arid Tropics* (India : ICRISAT)