The effectiveness of fertilizing to increase growth and productivity sorghum on dry land and marginal in Southeast Sulawesi

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Abstract. Sorghum is one of the food crops classified as cereal plants that have the potential to be cultivated and developed on marginal and dry land. Sorghum has characteristics that are able to adapt to drought and infertile environments. This plant has many benefits including being used as forage feed for ruminants, bioethanol, coating materials, sweeteners and organic materials as well as industrial raw materials. The availability of sorghum in the community is still limited because of its low production due to the use of low-yielding seeds and cultivation techniques that are not yet optimal especially fertilization. The provision of organic and inorganic fertilizers can be a solution for marginal land in Southeast Sulawesi. By regulating the availability of water for sorghum plants so that sorghum production can be increased and sustainable.

1. Introduction
An effort to reduce dependence on sources of carbohydrate such as rice and imports of wheat is through program accelerated diversified of food. The program is implemented more intensively by the ministry of agriculture in early 2018. The program aims to develop other food sourced from local commodities rich nutrition and safe for consumption. Meanwhile, income and the understanding of the community about increasing healthy life as well as rice, reducing consumption that trend national rice consumption fell. But this decline is still far from the level of consumption the countries of Asia such as; Korea, Japan, Thailand and Malaysia [12].

Sorghum (Sorghum bicolor L. Moench) is a plant of cereal grains that had the potential to cultivated and developed in Indonesia especially for the regions have land marginal [28] and dry land. Sorghum has done much of developed in several regions in Indonesia such as: on the island of Java, South Sulawesi, Southeast Sulawesi, West Nusa Tenggara, and East Nusa Tenggara [6]. Plant sorghum was not so popular by the public as food and not as popular as rice and corn, because sorghum was known better as the feed for ruminants [25], a layer of material, sweetening, industrial and organic, as well as the world export commodities. In addition, stems and biomass sorghum are potential to be used as raw material that produces bioethanol [18]. While sorghum has many benefits to be used as a substitute for the food rice. These plants capable of being adapted to arid climates have land with the wives of your own, less a tenure of lands and risk under cultivation that high [30], and relatively impervious to disorder pest and disease.
Southeast Sulawesi is areas that could potentially in the development and the increased production of sorghum national. But, one of the obstacles in the cultivation of plants sorghum in Southeast Sulawesi, the nature of the land dominant kind of ultisol or podzolik red to yellow, that require production inputs enough. In this type of soil has a low fertility rate, such as low soil pH or high soil acidity and Al saturation, low organic matter content, and macro nutrient deficiency [32]. Furthermore, Fe levels are very high, base saturation and CEC are low [31]. In addition, the characteristics of dry land are very limited in the availability of water, so that it becomes a concern in the use of agricultural land to support optimal sorghum production.

The plant of sorghum adaptive, and readily grows, but sorghum production in Indonesia was still low and very rare in the market, this might be due to low cultivation technique and low usage of superior varieties. To overcome the low production, several ways should be done through intensification. Intensification is a good option for narrow agricultural on dry land in Indonesia, so we needed to improve techniques of cultivation through locations specific fertilizing.

Research on dry land in Southeast Sulawesi for the development of sorghum commodities is still very extensive despite the limited number of sorghum farmers. Therefore, further research is still needed to examine the effectiveness of fertilization on marginal dry land in Southeast Sulawesi. The purpose of this paper is to determine the effectiveness of fertilization in increasing sorghum productivity in marginal land in Southeast Sulawesi.

2. Discussion

2.1. Varieties, Agroecosystem and Farming System of Sorghum Growth

Sorghum plant is food crops that have a good adaptation in the areas of the lowland and of upland regions. In general varieties sorghum that producing high on old varieties in (> 95 days) and used as feed (forage sorghum). The sweet sorghum constituting a variety high of biomass and used as fodder and liquid. The sweet sorghum biomass results achieved 34.5-63.4 tons/ha [29].

The sorghum plants can emerge from stems that have been harvested land can be harvested later (plants ratoon). Sorghum plants can be harvested two to three times, including the primary plants and ratoon, so it can provide the raw materials, carbohydrates forage cattle feed or material bioethanol sustainably [35]. The use high ratoon plants of sorghum are more efficient in terms of the cultivation because, it reduces the labour of costs, land management, time for planting, expenses costs seeds and energy [7]. Several varieties of sorghum new superior are presented in Table 1.

| No. | Name of varieties | Detachable year | Yield potential (tons/ha) | Harvest age (day) | Plant height (cm) | Long panicles (cm) | Appearance of panicles |
|-----|------------------|-----------------|---------------------------|-------------------|------------------|--------------------|------------------------|
| 1   | No. 6C           | 1970            | 4.6-6                     | 96-106            | 165-238          | 19-20              | ellipse               |
| 2   | UPCA-S2          | 1972            | 4.0-4.9                   | 105-110           | 180-210          | 22-26              | Pyramid               |
| 3   | KD4              | 1973            | 4.0                       | 90-100            | 140-180          | 20-24              | ellipse               |
| 4   | Keris            | 1983            | 2.5                       | 70-80             | 80-125           | 19-20              | ellipse               |
| 5   | UPCA-S1          | 1985            | 4.0                       | 90-100            | 140-160          | 20-22              | ellipse               |
| 6   | Badik            | 1986            | 3.0-3.5                   | 80-85             | 145              | 20-21              | ellipse               |
| 7   | Hegari Genjah    | 1986            | 3.0-4.0                   | 81                | 145              | 19                 | ellipse               |
| 8   | Mandaun          | 1991            | 4.0-5.0                   | 91                | 153              | 23                 | Pyramid               |
| 9   | Sangkur          | 1991            | 3.6-4.0                   | 82-96             | 150-180          | 20-25              | ellipse               |
| 10  | Numbu            | 2001            | 4.0-5.0                   | 100-105           | 187-00           | 22-23              | ellipse               |
| 11  | Kawali           | 2001            | 4.0-5.0                   | 100-110           | 135-00           | 28-29              | ellipse               |
| 12  | Super 1          | 2013            | 5.75                      | 105-110           | 216-50           | 26-67              | ellipse               |
| 13  | Super 2          | 2013            | 6.33                      | 115-120           | 229-71           | 26-38              | symmetric             |
| 14  | Suri 3 Agritan   | 2014            | 22.5                      | 95                | 230-4           | 29.1               | symmetric             |
| 15  | Suri 4 Agritan   | 2014            | 25                        | 95                | 239-4           | 29.7               | floppy                |
The commodities of sorghum that has the value of its peculiar flavour and good to be consumed as well as having high nutritional value. The nutrients in some new plant varieties superior of sorghum can be presented in Table 2.

| No. | Varieties       | Detachable year | proteins (%) | Fat (%) | carbohydrates t (%) | Tannin (%) | taste rice |
|-----|-----------------|-----------------|--------------|---------|---------------------|------------|------------|
| 1   | No. 6C          | 1970            | 9.7-10.4     | 2.67    | 26.40               | 1.19       | Less       |
| 2   | UPCA-S2         | 1972            | 9.25         | 3.60    | 64.25               | 0.35       | less       |
| 3   | KD4             | 1973            | 9.92         | 4.90    | 60.50               | 0.20       | less       |
| 4   | Keris           | 1983            | 6.38         | 3.60    | 25.20               | 1.12       | medium     |
| 5   | UPCA-S1         | 1985            | 9.0          | 5.70    | 66.50               | 0.22       | less       |
| 6   | Badik           | 1986            | 9.25         | 4.00    | 26.10               | 0.12       | good       |
| 7   | Hegari Genjah   | 1986            | 9.44         | 4.90    | 24.30               | 0.13       | good       |
| 8   | Mandau          | 1991            | 12.0         | 3.00    | 76.00               | 0.16       | medium     |
| 9   | Sangkur         | 1991            | 11.0         | 3.50    | 61.50               | 0.15       | medium     |
| 10  | Numbu           | 2001            | 9.12         | 3.94    | 84.50               | 0.18       | medium     |
| 11  | Kawai           | 2001            | 8.81         | 1.97    | 87.87               | -          | less       |
| 12  | Super 1         | 2013            | 12.96        | 2.21    | 71.32               | 0.11       | -          |
| 13  | Super 2         | 2013            | 9.22         | 3.09    | 75.62               | 0.27       | -          |
| 14  | Suri 3 Agritan  | 2014            | 16.02        | 2.52    | 64.06               | 0.077      | -          |
| 15  | Suri 4 Agritan  | 2014            | 15.42        | 3.96    | 64.93               | 0.013      | -          |

Table 2. shows that the taste of rice included in the delicious category of sorghum is the Badik and Hegari Genjah varieties, while for the medium rice flavor categories are the Keris, Mandau, Sangkur and Numbu varieties. For other sorghum varieties, the taste of rice is not preferred.

2.2. The Potential Dry Land Development of Sorghum in Southeast Sulawesi

Dry land in Southeast Sulawesi is suboptimal and it is potential for the development of sorghum. Dry land in Southeast Sulawesi was 562.263 ha in total. In 2016, 80.74% of the dry land in Southeast Sulawesi was used by agricultural. The cultivated agricultural land is 3.33% as wetland rice and 77.41% of agricultural land outside of wetland rice. Based on this, it is still quite extensive for the development of sorghum plants. The development of sorghum was competing with commodity crops corn, soybeans and tubers. The development of sorghum in Southeast Sulawesi still has difficulty due to the low fertility of the soil and low water availability for growth and productivity of sorghum. The land of agricultural in Southeast Sulawesi generally dominated by a type of soil ultisol. The character land of ultisol having a pH land and mineral reserve low, easy decayed aluminum high levels, the process of leaching because intensive. This, soil fertility depends on the level of organic material the topsoil [11]. The solution recommended through technique intensification fertilizing plants of sorghum. This application is reasonable enough part of the package to fertilizing with doses which are proper becoming in consideration of technological innovations in the farming system of sorghum. Fertilizing package of technology to increase the productivity of sorghum on dry land in Southeast Sulawesi, are rare so that farmers have had little adoptions the technology innovation.

Sorghum growing needs certain requirements, especially the climate condition, water supply, biophilic land condition and chemistry, danger erosion and floods and cultivation of the land. Southeast Sulawesi is dry land will be S1-S3, so sorghum needs input in the cultivation high production can improve the level of the land. The determination of the land suitability level is based on the topographic shape of Southeast Sulawesi in general with bumpy or mountain surface (slope> 40%), low hilly (slope 15-25%), and high hilly (slope 25-40%) [4],[11]. The soil texture to the top soil consisting of loam, clay, loam clay, dusty sandy clay, loam sandy loam soil and sand that can be described as having the nature of a bit rough. The land suitability levels for sorghum farming consist of: very suitable (S1), suitable (S2), less suitable (S3) and not suitable (N) can be presented in Table 3.
### Table 3. The criteria for the consistency of area making an agreement to development of sorghum plant [13]

| Land conditions                     | S1    | S2       | S3       | N      |
|-------------------------------------|-------|----------|----------|--------|
|                                     | (Completely suitable) | (suitable) | (Somewhat suitable) | (Not suitable) |
| Temperature °C                      | 25-27 | 27-30    | 30-35    | >35    |
| An elevation place                  | <200  | 200-1200 | 1200-2000 | >2000  |
| Rainfall (mm/years)                 | 400-900 | 900-1200 | 1200-1400 | >1400  |
| Length of time for dry (Month)     | 4-8   | 2.5-4    | 1.5-2.5  | <1.5   |
| Humidity (%)                        | <75   | 75-85    | >85      | Very hampered, fast |
| Drainage                            | Fine, somewhat obstructed | Quick bit was, in the middle | hampered | |
| Soil texture                        | Smooth, and smooth, somewhat | - | Somewhat rough | Rough |
| The depth of land (cm)              | >60   | 40-60    | 25-40    | <25    |
| Retention soil nutrients            | Clay cation exchange capacity (cmol) | >16 | ≤ 16 | |
| Base saturation (%)                 | >50   | 35-50    | < 35     | |
| pH H2O                              | 5.5 - 8.2 | 8.2-8.5  | >8.5     | |
| C-Organic (%)                       | >0.4  | <0.4     |          | |
| The danger of erosion (eh)          | < 8   | 9-15     | 16-50    | > 50   |
| The danger of flooding              | Very low | Low weight |          | Very weight |
| Puddle                              | F0    | F1       | F2       | > F2   |
| Land preparation                    | Rocks the surface (%) | < 5 | 6-5 | 15-40 | > 40 |
| Outcrop rocks (%)                   | < 5   | 6-5      | 15-25    | > 25   |

#### 2.3. Land Optimization and Improved Technology for Accelerating Sorghum

Sorghum plants in addition to consumption can also be used as animal feed. Providing nitrogen and phosphorus fertilizers can increase the yield and protein content and nutritional value of sorghum plants. Nitrogen from urea is an important nutrient in increasing the productivity of plant forage biomass [10]. The phosphorus nutrients are the main limiting factor in dry land, because the phosphorus nutrients are fixed by aluminum and iron [9]. The phosphor in organic fertilizer has given to the growth of plants useful of sorghum. According to [8], had been that the P fertilizer to cause receipt of P to increase caused by the presence of higher concentration P in the medium or because of extra roots. The root can actively absorb the phosphorus nutrients from the soil solution into the plant body in high concentrations. Therefore, phosphorus nutrients for sorghum plants play a role in growth and increase root absorption. The dose of 200 kg / ha of phosphorus fertilizer (P) has a significant effect on plant height, stem diameter, leaf length and width, seed production, biomass and crop harvest index [19].

The application of phosphorus (P) nutrients can increase sorghum tolerance to aluminum stress. This is shown in the growth of root length which is inhibited by reduced aluminum, where the role of the element phosphorus (P) is more effective, especially in the genotype formation phase for more tolerant varieties of Sorghum Numbu. The element phosphorus plays a role in root tissue by reducing the accumulation of aluminum, which is characterized by the intensity of hematoxylin staining which is lighter in sorghum Numbu varieties. The effect of aluminum pressure can increase the secretion of oxalic acid so that it is suspected that the element of phosphorus can reduce the secretion of oxalic acid. Provision of phosphorus plays a role in increasing the resistance of sorghum plants to aluminum pressure which may be related to the inhibition of aluminum absorption into the root tissue, although the mechanism is not yet known [16].

#### 2.3.1. Effectiveness of Organic Fertilizers in Increasing Sorghum Production

The application of organic fertilizer into the soil can have an influence on the production of biomass and sorghum liquid waste. Appropriate dosage of organic fertilizer for the production of biomass and
liquid sorghum ratoon I good and high of 10 tons / ha and the effect is not much different from the dose of 15 tons/ha. Numbu sorghum varieties show the best response to the production of biomass and liquid waste when ratoon is 5 weeks after planting and Keller variety when ratoon is 10 weeks after planting [22].

Organic fertilizer application can increase the growth and yield of sorghum plants. According to the research of [21] that the best dose for the highest weight of wet sorghum seeds in the combination of organic fertilizer and varieties was 15 tons / ha in Numbu varieties weighing 137.77 g per panicle or equivalent to 8.6 tons/ha. The best yield of sorghum biomass in the Keller and Wray varieties was 3.52 kg and 2.85 kg per 5 plants, respectively.

The use of sorghum in addition to consumption as well as animal feed demands that the production of feed forage be increased. One way to increase the production of forage in sorghum plants is through the provision of organic fertilizer. According to [25] that the dose of organic fertilizer 6.5 tons / ha had the best effect on the variable plant height, number of leaves and leaf length of sorghum plants. Furthermore according to [14] that organic fertilizer with a dose of 7.5 tons / ha in corn plants was able to obtain an average leaf length of 82.33 cm.

2.3.2. Effectiveness of Inorganic Fertilizers in Increasing Sorghum Production

The use of different doses of phosphorus fertilizer on some sorghum varieties can provide a noticeable difference to the increase in production. Based on the results of the study showed that the provision of phosphorus fertilizer dosages of 90 kg/ha gave the highest production in Pahat varieties 8.5 tons/ha and Mandau varieties 8.7 tons/ha, and the dose of phosphorus fertilizer 135 kg/ha in Kawali varieties the highest production was 9.0 tons/ha [27]. Based on the results of research [17] that the Numbu and Mandau varieties with the same phosphorus dose of 135 kg/ha given phosphorus fertilizer were able to improve the physiological quality of the best seeds compared to Kawali and Chisels varieties. According to [26] that the highest fat content was owned by Numbu and Mandau 3.52 at the dosage of phosphorus fertilizer 45 kg/ha and 135 kg/ha best fat content in Kawali varieties 2.82% and Chisels 2.79%.

Fertilization treatment showed a significant effect on the weight of dried seeds per plant, by giving fertilizer three times at the first dose 111 kg/ha Urea, 200 kg/ha SP36 and 72 kg/ha KCl, the second 107 kg/ha Urea and 72 kg/ha KCl, and third 44 kg/ha Urea and 72 kg/ha KCl. Provision of sufficient potassium can activate the absorption of nutrients and minerals used in the metabolic process of sweet sorghum plants [30]. Yields in Numbu varieties were higher at a combination of 25% P fertilizer plus 75% K, which was not significantly different from sorghum plants that were fertilized 100% P plus 100% K and 75% P plus 25% K. At the fertilizer dose 0% P plus 100% K is the treatment with the lowest yield. This is indicated because the result is not fulfilling the availability of P elements sufficient for the process of plant growth and development [20].

Application of inorganic fertilizer to sorghum plants for latosol soil types with moderate fertility based on maximum yields can be recommended 160.4- 43.7-124.9 kg N-P2O5-K2O ha⁻¹ or 348.6 - 121.3 - 208.1 kg Urea-SP36-KCl ha⁻¹ with the achievement of relative plant productivity of 94.76%, and optimum fertilization in the Cikarawang field, Darmaga, Bogor for sorghum 160.4-43.7-124.9 kg N-P2O5-K2O ha⁻¹ [33].

2.3.3. The effectiveness of NPK Organic and Inorganic Fertilizers Use

Based on the research results of [24], application dosage of 75% N, P, K fertilizer and 5 tons / ha organic fertilizer and 10.57 C-organic content gave the best significant effect on dry seed weight per plant and seed yield. The application of organic fertilizer of 5 tons / ha is able to give the best effect on panicle length, panicle weight per clump and seed weight per plant. Meanwhile, the administration of 5 tons / ha of manure plus 7.5 ml rabbit urine / ha with C-organic content of 13.28 provides the best effect on the yield of sorghum seeds. In the results of these studies it can be recommended that the range of use of NPK fertilizer for sorghum plants grown in Jatinangor rainfed is the best 75% of a dose of 150 kg / ha Nitrogen, 93.75 kg / ha Phosphate, and 37.5 kg / ha Potassium.
The use of organic fertilizer combined with NPK has a significant influence on the growth of plant height, stem diameter, number of leaves, flowering age and long panicles of sorghum plants. Using the best dose of organic fertilizer from chicken manure and NPK 2 tons / ha and 600 kg / ha NPK, organic fertilizer from goat manure and NPK provide the highest growth and productivity in sorghum plants compared to controls [2].

Provision of fertilizer 10 tons / ha, and biochar 900 kg / ha and phosphorus fertilizer from TSP 100 kg P2O5 / ha can affect the growth and levels of calcium (Ca) forage for sweet sorghum plants. This is demonstrated through the provision of organic fertilizer treatment plus P fertilizer and without biochar can increase the height of sorghum plants in the second cut. In addition, the treatment of manure plus TSP plus biochar produced the highest levels of Ca and forage sorghum feed at the first cut [3].

2.4. Challenges

According to [15], a combination of organic and inorganic fertilizers can increase the growth and production of Wakumoro cultivar sorghum on marginal land in Southeast Sulawesi. This is evidenced by observations of plant height, stem diameter, number of leaves, leaf area, dry weight of plant trimming, panicle length, panicle fresh weight, seed weight per panicle and weight of 1000 Wakumoro cultivars. The best treatment of the growth and production of local cultivar sorghum plants on the provision of organic fertilizer and a half dose of inorganic fertilizer (Biogreen organic fertilizer 5 tons ha$^{-1}$ or 2.25 kg plot$^{-1}$ and Urea fertilizer 100 kg ha$^{-1}$, SP36 50 kg ha$^{-1}$ and KCl 20 kg ha$^{-1}$ or Urea 45 g plot$^{-1}$, SP36 22.5 g plot$^{-1}$ and KCl 11.25 g plot$^{-1}$). The results of observations in the adaptation test of several sorghum varieties to plant height, fresh biomass weight, dry biomass weight, harvest age, weight 1000 per grain and productivity in dry land in Cimerak District, Ciamis Regency are presented in Table 4.

Table 4. The Average plant height, fresh biomass weight, dry biomass weight, harvest age, weight of 1000 grains and productivity of some sorghum varieties in dry land in Cimerak District, Ciamis Regency [34].

| Variabel                  | Numbu   | Kawali   | Unpad 1 | Unpad 2 | Batari  | Keller | Taomitsu |
|---------------------------|---------|----------|---------|---------|---------|--------|----------|
| Plant height (cm)         | 162.24 b| 128.60 bc| 158.52 b| 160.71 b| 212.82 a| 219.40 a| 98.24 c  |
| fresh biomass weight (g)  | 504.43 a| 487.22 ab| 464.64 b| 498.81 a| 376.17 cd| 369.36 cd| 403.92 c |
| dry biomass weight (g)    | 84.14 a | 78.24 a  | 72.87 ab | 78.44 a | 51.42 bc| 51.16 bc| 62.37 b  |
| harvest age (days)        | 106     | 110      | 108     | 110     | 138     | 145     | 89       |
| weight of 1000 grains (g) | 36.43 a | 30.28 b  | 32.52 ab | 34.27 a | 30.60 b | 31.34 b | 30.12 b  |
| Productivity (tons/ha)    | 4.12 a  | 3.92 a   | 3.86 ab  | 4.10 a  | 3.26 bc | 3.04 c  | 3.44 b   |

Notes: The number followed by the same letter shows no significant difference according to Duncan's test at 5% level; early age = <90 days, medium age = 90-120 days, and age within => 120 days.

Table 4. shows that some of the sorghum varieties used in this test were able to adapt to dry land in Ciamis Regency, West Java Province. In addition, the Numbu, Unpad 2 and Kawali varieties provide the best growth and productivity response compared to other varieties, so they are considered to be potential to be developed on dry land in the study site.

Application of organic fertilizer from sheep in marginal land ex the red brick mining industry did not have a significant effect on the growth and production of sorghum plants at the time of observation 4, 5 and 6 weeks after planting. This is caused by organic fertilizer from sheep still undergoing the process of decomposition by microorganisms as an energy source, so that organic material is not optimally available. The application of organic fertilizer at a dose of 7.5 kg / m2 is the best treatment compared to other treatments [5].

Numbu and Kawali varieties respond to the best growth and production components. The provision of organic fertilizer from chicken manure is able to provide the best growth and production of human sorghum compared to organic fertilizer from cow manure, goat manure, vermicompost and control. This is indicated by variable plant height, number of leaves, root length, root volume, panicle length,
weight per 1000 grains, stem diameter, weight of fresh biomass, weight of dry biomass, liquid waste content and sugar content. Therefore, these two varieties of Numbu and Kawai have the potential to be developed in Karanganyar and Ngawi Regencies [23], even on dry land throughout Indonesia.

3. Conclusion
The provision of organic and inorganic fertilizers has a significant influence on the growth and production of several varieties of sorghum plants. Inorganic fertilizers given can be Urea as a source of nitrogen, SP36 as a source of phosphorus and KCl as a source of potassium. Provision of organic fertilizer can from chicken and rabbit manure can improve and increase soil fertility in dry and marginal land. The use of organic and inorganic fertilizers in the best dosages can increase the growth and production of some sorghum varieties. The varieties of sorghum having the best in provision of organic and inorganic fertilizers on to increasing growth and productivity are varieties Badik, Hegari, Keris, Mandau, Sangkur, Kawai, Numbu, and cultivar Wakumoro.

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