Sorghum plants with ratoon cultivation increase production and income

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Abstract. Sorghum has broad adaptability, drought tolerance, high production, has strong and deep roots so that it can grow back after being harvested (ratoon) which can reduce production costs, with ratoon sorghum cultivation it can increase production and income. This study aims to determine the benefits of sorghum farming with ratoon cultivation which can increase farmers' production and income. Research was conducted in Jeneponto Regency, South Sulawesi, March-September 2018. Research consisted of eight sorghum lines and Numbu variety, using Randomize Block Design of three replications. Spacing 75 cm x 20 cm 1 plant/hole. The main fertilizing plants were 300 kg urea + 100 kg SP36 + 100 kg KCl ha⁻¹, and ratoon plants were 150 kg urea + 50 kg SP36 + 50 kg KCl ha⁻¹. Results showed that average yield of main crop was 5.92-6.57 t ha⁻¹, and ratoon 4.85-5.83 t ha⁻¹. Revenue obtainedmain cropRp. 11,840,000-13,140,000 and ratoon Rp. 9,706,000-11,660,000 ha⁻¹. Benefit of sorghum farming using ratoon system is Rp. 4,843,000-5,950,000 ha⁻¹, and Rp. 6,729,000-Rp. 8,572,000 ha⁻¹ for ratoon system. with two harvests, farming benefits range from Rp. 11.5 million-14.5 million ha⁻¹. This is supported by efficient use of sorghum ratoon farming to produce 1 kg of sorghum seeds at a cost of only Rp. 530-615 or more cost efficient up to 49.47% of main crop. Thus, sorghum farming with ratoon cultivation is very helpful for farmers because there is additional production and income so that it is feasible to develop.

1. Introduction
On marginal land, sorghum has several advantages compared to other food crops. Sorghum has a broad adaptability, drought tolerance, uses low inputs, high productivity, and is more resistant to pests and diseases [1, 2]. Sorghum has strong and deep roots so that it has the ability to grow back after being harvested (ratoon) which can reduce production costs [3]. Sorghum is very efficient in utilizing nutrients and water so that even in critical soils it can grow and produce [4, 5].

Sorghum is a versatile crop that can be used as a source of food, feed, and industrial raw materials. The seeds can be processed into food because they have fiber and contain various important minerals for human health [6], the stems contain sugar and can be processed into sorghum sugar which is very beneficial for human health and into bioethanol through fermentation as a fuel that is safe for the environment [7, 8, 9], fresh leaves and waste can be used as feed [10].
Sorghum stems contain sugar and can be processed into sorghum sugar which is very beneficial for human health and becomes bioethanol through fermentation as an environmentally safe fuel. Sorghum as an annual crop that is drought tolerant and does not require much water during its growth, making this plant commonly found in dry and rainfed areas. This plant has multiple functions and almost no plant parts are wasted starting from the seeds, leaves, stems and roots [11]. This benefit of sorghum is very useful because it has economic value so that it can be a source of income for farmers. For this reason, the optimal production of sorghum is sought, so we need a technology, in this case the cultivation technology of sorghum ratoon, which can increase production and increase farmers’ income.

Cultivation of sorghum ratoon system is a practical technology to get results in a relatively fast time because it has a shorter lifespan and can reduce production costs, as well as the use of labor. The same thing explained that the advantages of ratoon cultivation in sorghum, namely its relatively short lifespan compared to the main crop, less water requirement, and lower production costs [12, 14]. With these advantages, sorghum is seen as a commodity that has prospects for widespread development.

To grow sorghum ratoon is determined by the main crop performance and harvesting techniques. The ability to grow ratoons is not the same for every sorghum strain/variety, genetic factors greatly determine the ability of the sorghum genotype to produce ratoon plants. The ability of sorghum to produce ratoons is influenced by internal factors (genetic and food reserves in roots and stems) and external factors such as water availability, soil fertility, sunlight, temperature, pests and plant diseases [15]. In this regard, research was conducted, with the aim of knowing the benefits of sorghum farming with ratoon cultivation which can increase the production and income of farmers so that it is profitable to support its development.

2. Materials and Methods

2.1 Research sites
The research was carried out in Bontoramba, Jeneponto Regency, South Sulawesi in March-September 2018. To determine the performance of sorghum farming with ratoon cultivation evaluated, an approach was carried out by following technical research activities in the field so that it was known the use of production facilities and labor from land preparation to harvesting.

The technical research studied consisted of 9 lines/varieties of sorghum for food, namely eight sorghum lines (prospective varieties) and one Numbu variety (comparison), which used a group design with three replications. The spacing used is 75 cm x 20 cm and 1 planthole-1. Using fertilizer as much as 300 kg urea + 100 kg SP36 + 100 kg KCl ha-1, given twice, the first 10 days after planting (HST) 50% of the urea fertilizer dose plus the entire SP36 fertilizer and KCl fertilizer dose. The second was given at the age of 30 days after planting with 50% of the remaining dose of urea fertilizer. Application of fertilizers in tugal 5-10 cm beside the plant. Plant maintenance is carried out such as giving water, weeding and planting until the main plant is ready for harvest.

Furthermore, after harvesting the main crop by cutting the stems, it is then reared to grow hundreds of plants. Ratoon plants were fertilized once with a dose of 150 kg urea + 50 kg SP 36 + 50 kg KCl ha-1 and given enough water. Thinning of ratoons was carried out at the age of 15 days by leaving one plant per hole. Plants are well cared for until ready to harvest.

Determination of respondent or farmer cooperator in coordination with the Department of Agriculture of Jeneponto Regency including field officers at the research location. The selected farmers are active and experienced farmers in farming, who are willing to accept and try technological innovations including sorghum cultivation.

2.2 Data and analysis method
Research data obtained through interviews with farmers to determine the cultivation of sorghum starting from land preparation, planting, maintenance to harvest and processing the results. Interviews and direct
observations on technical activities were carried out in order to obtain data and information relevant to farming activities.

For the analysis of sorghum farming on the main crops and ratoons, it is known from primary data from interviews with farmers and direct observations in the field. Primary data collected includes use and prices of production facilities (seeds, fertilizers, herbicides, irrigation), use and wages of labor, as well as production data and values.

The data collected was tabulated and then analyzed using input-output (benefit) analysis methods, technical efficiency, economic efficiency and the ratio of costs/kg grain[16,17].

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\text{Input − output analysis: } \frac{\sum_{i=1}^{m} Y_i \cdot P Y_i - \sum_{i=1}^{m} X_i \cdot P X_i}{\sum_{i=1}^{m} P X_i} \times 100\%
\]

\[
\text{Technical efficiency analysis: } \frac{\sum_{i=1}^{m} Y_i}{\sum_{i=1}^{m} X_i} \times 100\%
\]

\[
\text{Economic efficiency analysis (%): } \frac{\sum_{i=1}^{m} Y_i \cdot P Y_i / \sum_{i=1}^{m} X_i \cdot P X_i}{\sum_{i=1}^{m} P X_i} \times 100\%
\]

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\text{Ratio analysis of cost/kg of grain (Rp/kg): } \frac{\sum_{i=1}^{m} X_i \cdot P X_i / \sum_{i=1}^{m} P X_i}{\sum_{i=1}^{m} X_i \cdot P X_i} \times 100\%
\]

Where: \(\Pi\) = Benefit (Rp/ha)
\(\Sigma\) = Sum from i to m or i to n
\(Y_i\) = Production (kg/ha)
\(PY_i\) = Production price (Rp/ha)
\(X_i\) = Input
\(PX_i\) = Price of input (Rp/ha)
i \ldots m = Number of production obtained
i \ldots n = Number of inputs used

3. Results and Discussion

3.1 Sorghum ratoon cultivation

The basis of ratoon treatment is the ability of plants such as perennial (annual) plants that continue to grow more than one harvest cycle. This is possible because of the ability of the main plant after cutting to sprout shoots from the base of the stem, near the soil surface, to produce new plants. Sorghum cultivation using the ratoon system has been carried out in India, Hawaii, Australia, the Philippines, Indonesia, California in the United States, and Africa [18, 19].

Sorghum can be cultivated on dry land throughout the year or during the rainy and dry seasons [20,21]. The results of research by Tsuchihashi and Goto[22] showed that sorghum plants can produce ratoons in both the dry and rainy seasons, so they can be harvested 2-3 times. Opole [23] stated that sorghum with its queen capacity can increase the yield and income of farmers in Kenya.

Cultivation of sorghum by planting seeds and maintaining the ratoon after harvesting the main crop can overcome water shortages in the dry season and ratoon cultivation tends to be more drought tolerant than the main crop [21]. Another advantage of sorghum ratoon cultivation is the efficient use of costs, seeds, labor and time. Solamalai [24] in their research showed that ratoon plants require less water than the main
plant. Effendi [3] stated that the results of the ICHRISAT study also showed that in moist soil conditions ratoon cultivation gave 5-7% greater profits than replanting, besides that ratoon plants were more mature than the main crop.

3.2 Sorghum farming and ratoon
Eight sorghum lines and one variety (Numbu) were planted, the crops showed good growth in the main crop and in the second crop (ratoon) and gave a fairly high production. Azrai [25] explained that superior varieties that adapt to marginal environments accompanied by improved management of cultivation and farming to obtain high yields need to be provided for farmers.

After harvesting the main crop, the former stems that have been harvested are allowed to grow again for the sorghum queen plant at one plant per hole. This crop is well maintained, and fertilized with half the amount of fertilizer for the main crop. In this sorghum farming, the use of production facilities, labor and farming analysis are described below.

3.2.1 Use of production facilities
In the first (main) planting, the production facilities used were seeds, fertilizers, herbicides, and the provision of water for sorghum plantations which evaluated the same amount per ha, namely 7 kg seeds, 300 kg urea fertilizer + 100 kg SP-36 + 100 kg KCl with two applications, 4 liters of Gramoxon herbicide with 2 sprays, and 4 times the provision of water with a rental system, so the total cost used is Rp. 2,705,000/ha.

For ratoon cultivation, the production facilities used are more efficient because they do not plant seeds from scratch like the first crop. The ingredients used are only half NPK fertilizer from the first plant, namely urea 150 kg + SP-36 50 kg + KCL 50 kg/ha, as well as giving water twice. The number and types given were the same for all ratoon crop lines/varieties, with a cost of Rp. 1,155,000/ha (Table 1).

3.2.2 Labor use
The use of labor in the 9 main sorghum crops is not the same, the time varies (work days) for planting, fertilizing, weeding, sowing, harvesting and processing activities. This depends on several factors including the production achieved, skills in farming and the age of the farmer. This is in line with what [26] explained, the speed of work for workers is influenced by several factors, including the age of the workforce, experience and farming skills, cropping and land conditions, and production. The average number of working days for sorghum farming is 51-57 work days with a labor wage of Rp. 50,000/day, so the cost is Rp. 4,165,100-4,495,000/ha. For sowing weeding activities carried out in bulk (Rp 1,000,000/ha) and threshing seeds with a sheller machine costs Rp 100/kg (wages are adjusted to the cost of threshing seeds/kg in East Nusa Tenggara).

In the ratoon plantation, the use of labor is more time-saving in fertilizing until harvesting and processing, the average yield is 25-27 work days. Uses less time than the main crop, time efficiency reaches about 52%. The labor cost for ratoon sorghum is an average of Rp. 1,789,000-Rp. 1,933,000/ha and there is a saving in labor costs for ratoons of about 57% from the main crop. For details, see Table 2.

3.2.3 Grain yield
Productivity of the resulting seeds obtained from the main crop and sorghum ratoon. In the main crop, the average yield of seeds was 5.92-6.57 t/ha, and in ratoon the average yield was 4.85-5.83 t/ha. Ratoon production is determined by the main crop performance [27], [28] and harvesting technique [29].

Cultivation of sorghum with the ratoon system yielded more than 1 time because apart from the main crop, it also resulted in additional production obtained and had an impact on increasing income received and increasing profits from farming.
3.2.4 Analysis of sorghum and ratoon farming

In farming sorghum and ratoons, the cost of production facilities (Table 1) for the main crop is Rp. 2,705,000/ha and for ratoons, Rp. 1,155,000/ha. There is a reduction in the cost of ratoon crops of Rp. 1,550,000/ha or a cost-effectiveness of about 57%. In the use of labor (Table 2), the cost of the main crop used is around Rp. 4,165,100-4,495,000/ha while the ratoon plant is Rp. 1,789,000-1,933,000/ha, which shows a cost savings of Rp. 2,469,050/ha or about 57%.

The production cost of sorghum farming (cost of production facilities + labor costs) used by the main crop is Rp. 6,870,100 to Rp. 7,212,000/ha and the queen is Rp. 2,940,300-3,088,000/ha. The production costs vary because they are influenced by the amount of labor used. Based on the yield of sorghum achieved in the main crop, seed production was 5.92 t/ha to 6.57 t/ha, indicating that the revenue obtained was Rp. 11,840,000-13,140,000 (valued at seed yield of Rp. 2,000/kg according to the Bogasari purchase price). Meanwhile, ratoon seeds yield 4.85-5.83 t/ha with an income of Rp. 9,706,000-11,660,000/ha. The benefit of sorghum farming using the ratoon system, obtained from the main crop, is around Rp. 4,843,000-5,950,000/ha, and for the ratoon, the benefit is Rp. 6,729,000 to Rp. 8,572,000/ha (Table 3). The benefit achieved by sorghum cultivation with ratoon cultivation, the value of which is determined by the amount of revenue received with low production costs, and will affect higher farm efficiency. According to Rahman and Saryoko [30] that the income and profits of a farm are influenced by the cultivation techniques applied, the prevailing prices and the results achieved.
Table 1. Use of production facilities in the farming of several lines/varieties of sorghum and ratoon, Jeneponto Regency, South Sulawesi Province, 2018

| Means production | Line/Variety | No.11-2 | No.11-3 | No.11-5 | No.58-1 | No.86-1 | No.96-1 | No.103-1 | No.113-1 | Numbu |
|------------------|-------------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
| **Main Crops**   |             |         |         |         |         |         |         |         |         |       |
| Seed             |             |         |         |         |         |         |         |         |         |       |
| Physical (kg/ha) | 7           | 7       | 7       | 7       | 7       | 7       | 7       | 7       | 7       | 7     |
| Value (Rp/ha)    | 175,000     | 175,000 | 175,000 | 175,000 | 175,000 | 175,000 | 175,000 | 175,000 | 175,000 | 175,000 |
| Urea fertilizer  |             |         |         |         |         |         |         |         |         |       |
| Physical (kg/ha) | 30          | 30      | 30      | 30      | 30      | 30      | 30      | 30      | 30      | 30    |
| Value (Rp/ha)    | 570,000     | 570,000 | 570,000 | 570,000 | 570,000 | 570,000 | 570,000 | 570,000 | 570,000 | 570,000 |
| SP36 fertilizer  |             |         |         |         |         |         |         |         |         |       |
| Physical (kg/ha) | 100         | 100     | 100     | 100     | 100     | 100     | 100     | 100     | 100     | 100   |
| Value (Rp/ha)    | 240,000     | 240,000 | 240,000 | 240,000 | 240,000 | 240,000 | 240,000 | 240,000 | 240,000 | 240,000 |
| KCl fertilizer   |             |         |         |         |         |         |         |         |         |       |
| Physical (kg/ha) | 100         | 100     | 100     | 100     | 100     | 100     | 100     | 100     | 100     | 100   |
| Value (Rp/ha)    | 700,000     | 700,000 | 700,000 | 700,000 | 700,000 | 700,000 | 700,000 | 700,000 | 700,000 | 700,000 |
| Gramoxone        |             |         |         |         |         |         |         |         |         |       |
| Physical (l/ha)  | 4           | 4       | 4       | 4       | 4       | 4       | 4       | 4       | 4       | 4     |
| Value (Rp/ha)    | 220,000     | 220,000 | 220,000 | 220,000 | 220,000 | 220,000 | 220,000 | 220,000 | 220,000 | 220,000 |
| Water supply     |             |         |         |         |         |         |         |         |         |       |
| Physical         |             |         |         |         |         |         |         |         |         |       |
| Value (Rp/ha)    | 800,000     | 800,000 | 800,000 | 800,000 | 800,000 | 800,000 | 800,000 | 800,000 | 800,000 | 800,000 |
| **Amount**       |             |         |         |         |         |         |         |         |         |       |
| Physical         | 511         | 511     | 511     | 511     | 511     | 511     | 511     | 511     | 511     | 511   |
| Value (Rp/ha)    | 2,705,000   | 2,705,000| 2,705,000| 2,705,000| 2,705,000| 2,705,000| 2,705,000| 2,705,000| 2,705,000| 2,705,000|
| **Ratoon**       |             |         |         |         |         |         |         |         |         |       |
| Urea fertilizer  |             |         |         |         |         |         |         |         |         |       |
| Physical (kg/ha) | 150         | 150     | 150     | 150     | 150     | 150     | 150     | 150     | 150     | 150   |
| Value (Rp/ha)    | 285,000     | 285,000 | 285,000 | 285,000 | 285,000 | 285,000 | 285,000 | 285,000 | 285,000 | 285,000 |
| SP36 fertilizer  |             |         |         |         |         |         |         |         |         |       |
| Physical (kg/ha) | 50          | 50      | 50      | 50      | 50      | 50      | 50      | 50      | 50      | 50    |
| Value (Rp/ha)    | 120,000     | 120,000 | 120,000 | 120,000 | 120,000 | 120,000 | 120,000 | 120,000 | 120,000 | 120,000 |
| KCl fertilizer   |             |         |         |         |         |         |         |         |         |       |
| Physical (kg/ha) | 50          | 50      | 50      | 50      | 50      | 50      | 50      | 50      | 50      | 50    |
| Value (Rp/ha)    | 350,000     | 350,000 | 350,000 | 350,000 | 350,000 | 350,000 | 350,000 | 350,000 | 350,000 | 350,000 |
| Water supply     |             |         |         |         |         |         |         |         |         |       |
| Physical         |             |         |         |         |         |         |         |         |         |       |
| Value (Rp/ha)    | 400,000     | 400,000 | 400,000 | 400,000 | 400,000 | 400,000 | 400,000 | 400,000 | 400,000 | 400,000 |
| Amount          | Physical | Value (Rp/ha) | Total cost | Value (Rp/ha) |
|----------------|----------|--------------|------------|--------------|
| Physical       | 250      | 1,155,000    | 761        | 3,860,000    |
| Value (Rp/ha)  | 1,155,000| 1,155,000    | 1,155,000  | 1,155,000    |

Table 2. The use of labor in the farming of several lines/varieties of sorghum and ratoon, Jeneponto Regency, South Sulawesi Province, 2018

| Labor          | No.11-2 | No.11-3 | No.11-5 | No.58-1 | No.86-1 | No.96-1 | No.103-1 | No.113-1 | Numbu |
|----------------|---------|---------|---------|---------|---------|---------|----------|----------|-------|
| **Main plant** |         |         |         |         |         |         |          |          |       |
| **Planting**   |         |         |         |         |         |         |          |          |       |
| Labor (working day/ha) | 12 | 13 | 13 | 12 | 11 | 13 | 12 | 13 | 13 |
| Cost (Rp/ha)   | 600,000 | 650,000 | 650,000 | 600,000 | 550,000 | 650,000 | 600,000 | 650,000 | 650,000 |
| **Fertilization 2 times** |         |         |         |         |         |         |          |          |       |
| Labor (working day/ha) | 25 | 26 | 26 | 24 | 24 | 26 | 24 | 26 | 26 |
| Cost (Rp/ha)   | 1,250,000 | 1,300,000 | 1,300,000 | 1,200,000 | 1,200,000 | 1,300,000 | 1,200,000 | 1,300,000 | 1,300,000 |
| **Spraying 2 times** |         |         |         |         |         |         |          |          |       |
| Labor (working day/ha) | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Cost (Rp/ha)   | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |
| **Hoarding**   |         |         |         |         |         |         |          |          |       |
| Labor (working day/ha) | Job work | Job work | Job work | Job work | Job work | Job work | Job work | Job work | Job work |
| Cost (Rp/ha)   | 1,000,000 | 1,000,000 | 1,000,000 | 1,000,000 | 1,000,000 | 1,000,000 | 1,000,000 | 1,000,000 | 1,000,000 |
| **Harvest**    |         |         |         |         |         |         |          |          |       |
| Labor (working day/ha) | 12 | 13 | 13 | 13 | 11 | 12 | 12 | 13 | 12 |
| Cost (Rp/ha)   | 600,000 | 650,000 | 650,000 | 550,000 | 600,000 | 600,000 | 650,000 | 600,000 | 600,000 |
| **Panic drying** |         |         |         |         |         |         |          |          |       |
| Labor (working day/ha) | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Cost (Rp/ha)   | 150,000 | 150,000 | 150,000 | 150,000 | 150,000 | 150,000 | 150,000 | 150,000 | 150,000 |
| **Threshing grains** |         |         |         |         |         |         |          |          |       |
| Physical       | Rent    | Rent    | Rent    | Rent    | Rent    | Rent    | Rent    | Rent    | Rent |
| Cost (Rp/ha)   | 592,000 | 632,900 | 645,000 | 650,300 | 615,100 | 619,000 | 610,200 | 657,000 | 606,200 |
| **Amount**     |         |         |         |         |         |         |          |          |       |
| Labor (working day/ha) | 54 | 57 | 57 | 54 | 51 | 56 | 53 | 57 | 56 |
| Cost (Rp/ha)   | 4,292,000 | 4,482,900 | 4,495,000 | 4,350,300 | 4,165,100 | 4,419,000 | 4,250,200 | 4,507,000 | 4,406,200 |
| Description          | No.11-2 | No.11-3 | No.11-5 | No.58-1 | No.86-1 | No.96-1 | No.103-1 | No.113-1 | Numbu |
|----------------------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
| **Main Crops**       |         |         |         |         |         |         |         |         |       |
| Grain production (t/ha) | 5.92   | 6.33    | 6.45    | 6.50    | 6.15    | 6.19    | 6.10    | 6.57    | 606   |
| Revenue (Rp/ha)      | 11,840,000 | 12,658,000 | 12,900,000 | 13,006,000 | 12,302,000 | 12,380,000 | 12,204,000 | 13,140,000 | 12,124,000 |
| Production costs (Rp/ha) | 6,997,000 | 7,187,900 | 7,200,000 | 7,055,300 | 6,870,100 | 7,124,000 | 6,965,200 | 7,212,000 | 7,111,200 |
| Benefit (Rp/ha)      | 4,843,000 | 5,470,100 | 5,700,000 | 5,950,700 | 5,431,900 | 5,256,000 | 5,238,800 | 5,928,000 | 5,012,800 |
| **Ratoon**           |         |         |         |         |         |         |         |         |       |
| Grains production (t/ha) | 4.86   | 4.98    | 5.39    | 5.83    | 5.57    | 4.99    | 5.17    | 5.28    | 4.85  |
| Revenue (Rp/ha)      | 9,720,000 | 9,952,000 | 10,780,000 | 11,660,000 | 11,134,000 | 9,986,000 | 10,340,000 | 10,560,000 | 9,706,000 |
| Production costs (Rp/ha) | 2,991,000 | 3,002,600 | 2,944,000 | 3,088,000 | 3,011,700 | 2,954,300 | 2,972,000 | 2,983,000 | 2,940,300 |
| Benefit (Rp/ha)      | 6,729,000 | 6,949,400 | 7,836,000 | 8,572,000 | 8,122,300 | 7,031,700 | 7,368,000 | 7,577,000 | 6,765,700 |
| **Total benefit 2 times harvest** | 11,572,000 | 12,419,500 | 13,536,000 | 14,522,700 | 13,554,200 | 12,287,700 | 12,606,800 | 13,50,500 | 11,778,500 |

Table 3. Production, revenue, production costs and farming profits of the main crop and sorghum ratoon in several sorghum lines/varieties, Jeneponto Regency, South Sulawesi, 2018
3.3 Efficiency of ratoon sorghum farming system

Cultivation of sorghum with the ratoon system, by looking at the results obtained for both the main crop and the ratoon, shows that the yield is quite large with two harvests, so that the farming profit is quite large, ranging from Rp. 11.5 million to 14.5 million/ha. Sorghum cultivation with more than one harvest is very helpful for farmers' income.

Sorghum ratoon farming, besides being time efficient and also efficient in the use of production costs, can be seen in Table 4. In the ratoon plant compared to the main crop, the farming costs are more efficient, it can be seen in the lower cost/kg seed ratio of Rp 530-615/kg seeds, medium crop main amount is Rp. 1,085-1,182/kg seeds. This means that to produce 1 kg of sorghum seeds on ratoon plants only costs Rp. 530 to Rp. 615 or more cost efficient up to 49.47% of the main crop. Likewise, the use of inputs is also efficient, both technically and economically visible. Technically, each use of 100 kg of input yields 17-21 times the yield of ratoons, while the main crop yields 10-12 times as much. Economically, for every use of Rp 100, you will receive a revenue of 3-4 times for the queen and for the main crop it will be around 2 times.

Efficient use of inputs both technically and economically has a high impact on production and income. Therefore, the ratoon system of sorghum farming in addition to increasing the production of sorghum seeds is also operating income. It is also explained by Opole [23] that sorghum with its queen power ability can increase the yield and income of Kenyan farmers. Thus, sorghum with ratoon cultivation is very profitable so it is feasible to be developed and the cultivation technology needs to be socialized.

Table 4. Total production, revenue, costs and benefits of ratoon sorghum farming on several sorghum lines/varieties, Kab. Jeneponto, South Sulawesi, 2018

| Description | Line/Variety | No.1 | No.11-3 | No.11-5 | No.58-1 | No.86-1 | No.96-1 | No.103 | No.113 | Numb |
|-------------|--------------|------|--------|--------|--------|--------|--------|--------|--------|------|
| Main Crops  |              |      |        |        |        |        |        |        |        |      |
| Cost ratio/kg grains (Rp/kg biji) | 1,18 | 1,136 | 1,116 | 1,085 | 1,117 | 1,151 | 1,141 | 1,098 | 1,173 |
| Technical efficiency (%) | 1048 | 1114 | 1136 | 1151 | 1095 | 1092 | 1082 | 1157 | 1069 |
| Economic efficiency (%) | 169 | 176 | 179 | 184 | 179 | 174 | 175 | 182 | 170 |
| Ratoon      |              |      |        |        |        |        |        |        |        |      |
| Cost ratio/kg grains (Rp/kg biji) | 615 | 603 | 546 | 530 | 541 | 592 | 575 | 565 | 606 |
| Technical efficiency (%) | 1755 | 1796 | 1960 | 2105 | 2017 | 1809 | 1873 | 1913 | 1758 |
| Economic efficiency (%) | 325 | 331 | 366 | 378 | 370 | 338 | 348 | 354 | 330 |

4. Conclusions and Suggestions

1. Sorghum farming with ratoon cultivation is profitable for farmers because the increase in production results in an increase in income. Seed production obtained from the main crop was 5.92-6.57 t/ha and from the queen plant 4.85-5.83 t/ha, so that the total farming profit was Rp. 11.5 to 14.5 million/ha.

2. Farming ratoon sorghum is more cost efficient than the main crop. The cost ratio per kg of seeds is Rp. 530-615, while the main crop is Rp. 1,085-1,182/kg of seeds. Technically, for every use of 100 kg of input, the yield is 17-21 times and the main crop is 10-12 times, while economically, each use of Rp. 100 will give 3-4 times more revenue and up to 2 times for the main crop.

3. Sorghum cultivation with the application of ratoon cultivation means that farmers in farming can harvest more than once, thereby increasing production which has an impact on increasing farm income. This is very profitable for farmers and deserves to be developed and the cultivation technology needs to be socialized.

References
[1] Andriani A and Isnaini M 2013 Morfologi dan fase pertumbuhan sorgum Sorgum (Inovasi Teknologi dan Pengembangannya) p 47-68
[2] Tabri F and Zubachtirodin 2013 Budi daya tanaman sorgum Sorgum (Inovasi Teknologi dan Pengembangannya) p 175-87
[3] Efendi R, Fatmawati, and Zainuddin B 2013 Prospek pengembangan ratun sorgum Sorgum (Inovasi Teknologi dan Pengembangannya) p 205-21
[4] Bortgh E, Crusciol C A C, Nascente A S, Sousa V V, Martins P O, Mateus G P and Costa C 2013 Sorghum grain yield, forage biomass production and revenue as affected by intercropping time Eur. J. Agron. 51 130-9
[5] Syafri N and Akil M 2013 Pengelolaan hara pada tanaman sorgum. Sorgum (Inovasi Teknologi dan Pengembangannya) p 168-74
[6] Suarni and Firmansyah I U 2013 Struktur, komposisi nutrisi, dan teknologi pengolahan sorgum Sorgum (Inovasi Teknologi dan Pengembangannya) p 260-79
[7] Efendi R, Fatmawati, and Zainuddin B 2013 Prospek pengembangan ratun sorgum Sorgum (Inovasi Teknologi dan Pengembangannya) p 205-21
[8] Castro E, Nieves I U , Rondon V, Sagues W J, Fernandez-Sandoval M T, Yomano L P, York S W, Erickson J and Vermerris W 2017 Potential for ethanol production from different sorghum cultivars Ind. Crop Prod. 109 367-73
[9] Nasidi M, Agu R, Deeni Y and Walker G 2015 Improved production of ethanol using bagasse from different sorghum cultivars Biomass and Bioenergy 72 288-99
[10] Subagia H and Syuryawati 2013 Wilayah penghasil dan ragam penggunaan sorgum di Indonesia Sorgum (Inovasi Teknologi dan Pengembangannya) p 24-37
[11] Benyamin 2017 Sorgum dari Daun Sampai Akar Berguna Bisa Jadi Duit (Team Yaspensel)
[12] Liu X, Feng D, Yu G, Zhao H, Qiao L, Li Y, Fan X, Liu M and Zhang Q 2016 Effect of different sowing dates in Shout Henan’s rice growing areas on the growth and yield of ratoon rice Asian Agric. Res. 8 43-7
[13] Hanafie R 2010 Pengantar Ekonomi Pertanian (Yogyakarta (ID): CV. Andi Offset)
[14] Gardner B, Pearce and Mitchell R L 1991 Physiology of crops plants The Iowa State University.
[15] Enserink H J 1995 Sorghum agronomy in West Kenya: Investigation from a farming systems perspective Royal Tropical Institute, Amsterdam, The Netherlands
[16] Tsuchihashi N and Goto Y 2004 Cultivation of sweet sorghum (Sorghum bicolor (L) Moench) and determination of its harvest time to make use as the raw material for fermentation, practiced during rainy season in dry land of Indonesia Plant Prod. Sci. 7 442-48
[17] Tsuchihashi N and Goto Y 2005 Internode characteristics of sweet sorghum (Sorghum bicolor (L) Moench) during dry and rainy season in Indonesia Plant Prod. Sci. 8 601-7
[18] Tsuchihashi N and Goto Y 2008 Year-round cultivation of sweet sorghum (Sorghum bicolor (L) Moench) through a combination of seed and ratoon cropping in Indonesian savanna Plant Prod. Sci. 11 377-84
[19] Opole R A, Mbunu C M and Lumuli J 2007 Improving ratoon management of sorghum (Sorghum bicolor (L) Moench) for increasing yields in western Kenya African Crop Science Conference Proceedings 8 143-46
[20] Solaimalai A, Ravisankar N and Chandrasekaran B 2001 Water management to sorghum-a review. Agrc. Rev. 22 115-20
[25] Azrai M, Human S and Sunarti S 2013 Pembentukan varietas unggul sorgum untuk pakan Sorgum (Inovasi Teknologi dan Pengembangannya) p 107-37
[26] Syuryawati and Faesal 2016 Kelayakan financial penerapan teknologi budidaya jagung pada lahan sawah tadah hujan. J. Penelitian Pertanian Tanaman Pangan 1 71-80
[27] Harrell D L, Bond J A and Blance S 2009 Evaluation of main crop stubble height on ratoonreece growth and development Field Crops Research 114 396-403
[28] Sanni K, Ojo D K, Adebisi M A, Somado E A, Ariyo O J, Sie M, Akintayo I, Tia D D, Ogunbayo S A, Cisse B, Sikirou M and Adekoya M A 2009 Ratooning potential of interspecific NERICA rice varieties (Oryzaglaberrima x Oryza sativa) Int. J. Bot. 5 112-5
[29] Susilawati, Purwoko B S, Aswidinnoor H and Santosa E 2012 Tingkat produksi ratun berdasarkan tinggi pemotongan batang padi sawah saat panen J. Agron. Indonesia 40 1-7
[30] Rachman B and Saryoko A 2008 Analisis titik impas dan laba usahatani melalui pendekatan dan pengelolaan padi terpadu di Kabupaten Lebak, Banten. J. Pengkajian dan Pengembangan Teknologi Pertanian 11 54-60