The growth and yield of several sorghum varieties in the first ratoon

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Abstract. At harvest, the stems of the sorghum plant are generally cut down and then it is left abandoned. Meanwhile, the remaining sorghum stems from the harvest have the potential to be regrown for the cultivation of ratoon. The advantages of ratoon cultivation are that it has a relatively shorter harvest time than the main crop, requires less water, and lower production costs. The aim of this study was to test the growth and yield of five varieties of sorghum, namely Numbu, Super 1, Suri 3, Keller, and Kawali in ratoon cultivation and to test the growth and yield of sorghum with several selections of the number of shoots in ratoon cultivation. The study used a factorial - Randomized Completed Block Design with 2 treatment factors, repeated 3 times. The first treatment was sorghum varieties consisting of Numbu, Super 1, Suri 3, Keller, and Kawali in ratoon cultivation and to test the growth and yield of sorghum with several selections of the number of shoots in ratoon cultivation. The study used a factorial - Randomized Completed Block Design with 2 treatment factors, repeated 3 times. The first treatment was sorghum varieties consisting of Numbu, Super 1, Suri 3, Keller, and Kawali. The second treatment was the number of shoots consisting of 1 shoot, 2 shoots, 3 shoots, and 4 shoots. Observational data were analyzed using analysis of variance with the F test at 5% level followed by Duncan’s multiple distance test. Observation variables included the height of plant, stem diameter, grain weight per clump, number of grains per clump, the weight of 1000 grains, and yield per plant. The results indicated that the highest plant in the Numbu variety, while the largest stem diameter was in the Kawali variety. The number of shoots 4 increased the grain yield per clump but decreased the plant height compared to the number of shoots that were less. The yield of grains per plot was higher on Super1 varieties as much as 604.33 g or 3.3 ton/ha, however the highest number of grains per clump was on Kawali varieties.

1. Introduction
Sorghum (Sorghum bicolor (L.) Moench) is a multipurpose plant that can be used as food [1] feed and energy in accordance with its many types and uses [2] . Sorghum is a plant that has been around for a long time in Indonesia and has been known in various regions under different names. Sorghum is a cereal crop that has the potential to be cultivated and developed, especially in marginal and dry areas in...
Indonesia. The vast potential of dry land in Indonesia is very suitable for development. Sorghum is more drought tolerant than other cereal crops. The efficiency of water use in sorghum is 52 kg ha\(^{-1}\) mm\(^{-1}\) while corn is 38 kg ha\(^{-1}\) mm\(^{-1}\) [3]. Another advantage of sorghum is its high adaptability to all fields, drought resistance, requires less cost in cultivation and is more resistant to pests and diseases [4]. Most research on sorghum in Indonesia is still on its use as food and how to expand its planting opportunities on dry lands [5].

In general, when sorghum is harvested, the stems of the plant are cut down and then left abandoned. Whereas, the remaining sorghum stems from the harvest have the potential to be regrown for ratoon cultivation. The ratoon in sorghum has long received the attention of many researchers because of the advantages of ratoon cultivation, namely, its lifespan is relatively shorter than the main crop, requires less water, and lower production costs.

The process for growing a ratoon, the stems of the first growing season crop are cut, allowed to regrow and cultivated like sorghum grown from grain. The yield of the main crop also has a significant and positive correlation with the yield of the ratoon [6]. To obtain high yields, ratoon sorghum plants must be developed from mature plants from the first plant by maintaining several shoots per clump [7].

The procedure for cultivating sorghum ratoon after the first harvest is in the first season immediately cutting the old stems in the middle of the second segment after harvesting. The soil around the sorghum plant is cleared of weeds or weeds. Do watering the plants in one week 1-2 times. Provide inorganic fertilizers, namely compound fertilizers containing N, P, and K elements around the sorghum planting holes. Fertilizer was applied at a dose of 2.5 kg for each plot. Fertilization is carried out for 2 times of fertilization, namely when the plant is 3 and 7 weeks after planting. New shoots that appear (ratoon) are well cared for as in first period plant maintenance, which includes weeding, fertilizing, and controlling the organisms that disturb the plant.

The advantage of sorghum is that this plant can be ratooned and the yield of ratooned once is still the same as the yield of ratooned sorghum [8], while the yield as bioethanol and animal feed for ratooned sorghum yields higher yields than once ratooned. The ability of meratoon and ratoon production can reach 49 - 66% of the main or first crop yield [8]. With the use of high ratoon power, it encourages sorghum cultivation to be more efficient because it can reduce labor costs, planting time period, tillage, and use of grains and energy.

The aim of this study consisted of two purposes. First, to test the growth and yield of five new varieties of sorghum in ratoon cultivation. The second is to test the growth and yield of sorghum with several selections of the number of shoots in ratoon cultivation.

2. Material and Methods

2.1 Study Area and Research Materials

The research was undertaken in January – April 2021. The land used was the Vertisol type and it was previously used for rice and chili cultivation. The land had an altitude of 104 m above sea level. The materials used were sorghum grains (Numbu, Super 1, Suri 3, Kawali, and Keller varieties), herbicides, and urea fertilizer. The tools used were hoe, meter, hose, ruler, scales, and stationery.

2.2. Experimental design

This research was conducted using a factorial - Completely Randomized Block Design with 2 treatment factors, repeated 3 times. This study consisted of two treatments. Treatment I was sorghum varieties, namely Numbu variety, Super 1 variety, Suri 3 variety, Keller variety, and Kawali variety. Treatment II was the number of shoots consisting of 1 shoot, 2 shoots, 3 shoots, and 4 shoots.

The sorghum plants in this study were sorghum stems produced from sorghum plants that have been harvested (primary plants from grains). The stems were squeezed in the middle of the second segment, then grown for up to 21 days. This growing shoot was maintained until harvest as a ratoon. Sorghum plants generally in 1 plant, there was only 1 shoot that was maintained.
2.3. Statistical Analysis
In this treatment, the number of shoots was up to 4. Thus, there are 1, 2, 3, and 4 in one plant. Plants were harvested when they met the harvest criteria at the age of 100 days after planting. Plant parameters observed included plant height, stem diameter, grain weight per clump, number of grains per clump, weight of 1000 grains, and grain yield per plot. Observational data were analyzed using analysis of variance with the F test at 5% level followed by Duncan's multiple distance test.

3. Result and Discussion

3.1 The Height of Plant
The results of the analysis of variance indicated that the use of the number of shoots was not significant from plant height, the results of significant were shown by the use of different varieties. Different varieties have morphological diversity, especially different heights. According to Andriani and [9] the height of sorghum plants depends on the variety, number and size of stem segments. The highest average plant in the Numbu treatment with the number of shoots 2 was 239.89 cm and the lowest in the Kawali treatment with the number of shoots 4 was 133.19 cm. The variety of Numbu has a plant height generally of ± 187 cm, with the position of the stem at the top, ribbon leaf shape, the number of leaves 14 strands, panicle nature: compact, panicle shape: elliptical, panicle length: 22-23 cm, with the shape / properties of grains: oval, easy to fall off. The treatment of varieties and the number of shoots do not interact with the parameters of sorghum plant height. In this study, the variety with the highest average plant height was the Numbu variety. The results discovered that the Numbu variety had a plant height of more than 2 meters. This is due to Numbu's supportive growing environment. The sorghum variety that is resistant to phosphorus deficiency is mentioned as Numbu [10] and [11].

The varieties with the next average height starting from the second highest to the shortest are Super 1, Keller, Suri 3, and Kawali varieties. Based on table 1, it is discovered that the treatment with 4 shoots had the lowest average plant height. The large number of shoots encouraged the competition which had an impact on plant height.

| Table 1. Average height of plants (cm) |
|---------------------------------------|
| Treatment    | 1 shoot  | 2 shoots | 3 shoots | 4 shoots | Average |
|---------------|----------|----------|----------|----------|---------|
| Numbu         | 239.56   | 239.89   | 231.30   | 235.83   | 236.64  |
| Super 1       | 183.56   | 187.06   | 225.74   | 192.14   | 197.12  |
| Suri 3        | 195.11   | 213.83   | 195.57   | 190.36   | 198.72  |
| Keller        | 204.22   | 219.43   | 227.59   | 183.39   | 208.66  |
| Kawali        | 142.89   | 167.94   | 142.44   | 133.19   | 146.62  |
| Average       | 193.07   | 205.63   | 204.53   | 186.98   | 146.62  |

Description: a number followed by the same letter in a row or column showed no significant in the test of Duncan of 5%

In the treatment with a low population, the variables show the best results. For instance, plant growth variables such as plant height and stem diameter. Populations that are denser and more tenuous (exceeding the optimum limit) tend to reduce plant growth. The decrease is due to the leaves in the population shelter each other, so then only the upper leaves receive sunlight. This results in photosynthetic activity in the optimum population, thus it affects plant metabolic processes [12].

3.2. Stem Diameter
The results of the analysis of variance indicated that all treatments, namely varieties and selection of the number of shoots produced significant results to stem diameter. The highest average stem diameter in the Kawali treatment with the number of shoots as much as 1 was 2.40 cm. The lowest stem diameter in
the Keller treatment with 4 shoots was 1 cm. There was no interaction between the variety treatment and the number of shoots treatment. The internode diameter character pointed out a significant difference between varieties. The sorghum stem segments in the center of the plant were generally long and uniform compared to the segments at the bottom and top of the plant. The longest segment was on the last segment (the tip of the plant), which was a panicle steam. The surface of the internodes of sorghum stems was similar to that of sugar cane, which covered by a thick layer of wax, except at the tips of the stems. The wax layer was mostly on the top of the leaf midrib, which served to reduce transpiration so that sorghum was tolerant to drought. Based on the results, the average stem diameter from the highest to the lowest was the Super 1 variety, the Numbu variety, the Suri variety 3, the Kawali variety and the Keller variety. Each different variety will have different advantages, in utilizing environmental factors such as water, light, and nutrients so that it can affect plant growth and development.

### Table 2. Average stem diameter (cm)

| Treatment | 1 shoot | 2 shoots | 3 shoots | 4 shoots | Average |
|-----------|---------|----------|----------|----------|---------|
| Numbu     | 1.35    | 1.11     | 1.50     | 1.33     | 1.32 a  |
| Super 1   | 1.44    | 1.23     | 1.50     | 2.14     | 1.58b   |
| Suri 3    | 1.81    | 2.00     | 2.00     | 1.42     | 1.81 c  |
| Keller    | 1.81    | 2.00     | 1.43     | 1.00     | 1.56 ab |
| Kawali    | 2.40    | 1.64     | 1.60     | 1.47     | 1.78 bc |
| Average   | 1.76 b  | 1.60 a   | 1.61 a   | 1.47 a   |         |

Description: a number followed by the same letter in a row or column showed no significant difference in Duncan test 5%

Based on table 2, it is found that the treatment with the number of shoots 1 had the highest average stem diameter. The less number of shoot treatments, the more optimal growth due to there is no competition. Nutrients can be absorbed optimally so that it has an impact on a large stem diameter.

### 3.3. The Weight of Grain per Clump

The results of the variance test showed that all varietal treatments and the number of shoots produced significant on the weight of grains per clump. The average weight of grains per clump was highest in the Keller treatment with the number of shoots 3 as much as 113.30 g and the lowest yield in the Suri 3 treatment with the number of shoots 3 being 11.10 g. In this study, there was no interaction between varieties and number of shoots. [13] stated that variety is a group of individual plants that can be distinguished by each characteristic (morphology, physiology, cytology, chemistry etc.) each different variety has different genetic abilities, each sorghum variety provides a different growth response to its growing environment [14].

### Table 3. Average grain weight per clump (g)

| Treatment | 1 shoot | 2 shoots | 3 shoots | 4 shoots | Average |
|-----------|---------|----------|----------|----------|---------|
| Numbu     | 23.52   | 20.17    | 12.04    | 22.32    | 19.51 a |
| Super 1   | 33.15   | 41.76    | 28.13    | 84.60    | 46.91 b |
| Suri 3    | 26.98   | 26.07    | 11.10    | 70.99    | 33.78 b |
| Keller    | 30.07   | 14.79    | 113.30   | 65.32    | 55.87 c |
| Kawali    | 18.76   | 35.98    | 15.60    | 28.77    | 24.78 ab|
| Average   | 26.50 a | 27.76 a  | 36.03 a  | 54.40 b  |         |

Description: a number followed by the same letter in a row or column showed no significant difference in the test of Duncan 5%
Plants with different varieties have different growth even though they are planted on the same soil. Grain weight per clump from highest to lowest were Keller variety, Super 1 variety, Suri 3 variety, Kawali variety, and Numbu variety. Meanwhile, from table 3, information is obtained that the more shoots, the more weight of grains per clump will be, and vice versa the fewer shoots the weight of grains per clump will also decrease. In general, sorghum plants in 1 plant stem only produce 1 panicle clump.

### 3.4. The Number of Grains per Clump

The results of the analysis of variance in the treatment of varieties produced significant results to the number of grains per clump. Meanwhile, the number of shoots treatment showed no significant difference in the number of grains per clump. There was no interaction between the two treatments. The average number of grains per clump was the highest on the Kawali variety, the number of shoots 4 was 3,508.06, the lowest was the Numbu variety, the number of shoots 2 was 560.49. The difference in the number of grains per clump was caused by the different number of grains per panicle and the size of the grains produced in each variety caused by genetic factors of the plant itself. [15] states that the potential yield of sorghum is influenced by the genetic characteristics of the variety, conditions or climate and the environment in which it grows and its cultivation treatment.

| Treatment | 1 shoot  | 2 shoots | 3 shoots | 4 shoots | Average  |
|-----------|----------|----------|----------|----------|----------|
| Numbu     | 591.60   | 560.49   | 653.70   | 657.44   | 615.81 a |
| Super 1   | 995.22   | 1,285.43 | 884.47   | 2,302.33 | 1,366.86 c |
| Suri 3    | 921.21   | 788.35   | 700.42   | 1,132.68 | 885.66 ab |
| Keller    | 1,049.90 | 694.07   | 987.26   | 980.00   | 927.81 bc |
| Kawali    | 1,818.37 | 3,112.60 | 2,752.85 | 3,508.06 | 2,797.97 c |

**Table 4. Average number of grains per clump**

Description: a number followed by the same letter in a row or column showed no significant in Duncan test 5%

Table 4 shows that variety 5, namely Kawali, has the highest average number of grains. The Kawali variety has the smallest grains compared to the other four varieties. With the same panicle size but small grain size, the highest number of grains will be obtained. The appearance of the yield component of an individual plant decreases at a high level of plant density (three and four plants/planting hole) due to competition, but in the acquisition of the yield component for an area of land there will be an increase compared to plants grown with low plant density (one and two plants/planting hole) or compensation. In optimal populations, competition between plants still occurs so that growth and yield per individual are reduced, however due to the number of plants per hectare increases with increasing population, yields per hectare can still increase.
Ratoon plants are sensitive to the effect of environment. Genotypes that can adapt to stressful environmental conditions, can produce good and stable ratoons. The stability of the main/primary plant is not always the same as the stability of the ratoon plant. Changes in varietal rank may occur between the main plant and the ratoon in different places [15].

3.5. The Weight of 1000 Grains
The results of the analysis of variance pointed out that the varieties and number of shoots were not significant in this study. There was no interaction between varietal treatment and the number of shoots. The average weight of 1000 grains was highest at Numbu, the number of shoots 1 was 42.24 g, the lowest was Kawali, the number of shoots 4 was 2.55 g. Different varieties grown in the same place showed that different responses to the components of plant growth and yield [17]. The Kawali variety had the smallest panicle and grain shape among the other varieties. Thus, the same number of grains as other varieties, the lowest grain weight will be obtained. According to [18], the greater the weight of 100 grains, the larger the size of the grains. Grain size can affect grain weight. Smaller grains are formed due to aging and ripening occurs more quickly.

Table 5. Average weight of 1000 grains (g)

| Treatment | 1 shoot | 2 shoots | 3 shoots | 4 shoots | Average |
|-----------|---------|----------|----------|----------|---------|
| Numbu     | 42.24   | 38.59    | 39.41    | 26.10    | 36.59 a |
| Super 1   | 33.69   | 38.96    | 24.98    | 36.86    | 33.63 a |
| Suri 3    | 30.56   | 21.43    | 26.05    | 21.65    | 21.15 a |
| Keller    | 29.92   | 32.18    | 10.97    | 24.80    | 28.24 a |
| Kawali    | 8.46    | 4.54     | 8.11     | 2.55     | 5.92 a  |
| Average   | 28.98 a | 27.14 a  | 21.90 a  | 22.39 a  | 5.92 a  |

Description: a number followed by the same letter in a row or column showed no significant in Duncan test of 5%

Table 5 points out that variety 5, namely Kawali, has the lowest average weight of 1000 grains. The Kawali variety has the smallest grains compared to the other four varieties. So when it is compared with other varieties with the same amount, it will obtain low weight. The weight of 100 grains is related to the quality of the grains produced by the plant. The weight of 100 grains is influenced by the availability of nutrients and the ability of plants to absorb, for example phosphorus in the phase of filling grain [18].

3.6. The Yield of Grain Per Plot
The yield of grains per plot was the yield of all plants of the same variety in one treatment plot. Based on the analysis of variance, the treatment of varieties produced significant results to the yield of grains.
per plot. Treatment of the number of shoots showed results that were not significant from the yield of grains per plot. There was no interaction between the variety treatment and the number of shoots treatment. The highest average yield on Super 1 number of shoots 4 was 604.33 g if converted as much 3.3 ton/ha, the lowest was Suri 3 with number of shoots 4 of 75.33 g or 0.4 ton/ha. The morphological and agronomic characteristics of sorghum had considerable diversity, so that the weight of sorghum was also influenced by varying qualitative characteristics such as varying panicle length and panicle type as well as the number of panicle branches, grain shape, and number of grains that vary in each species, each variety.

Table 6. Average grain yield per plot (g/plot)

| Treatment | 1 shoot | 2 shoots | 3 shoots | 4 shoots | Average |
|-----------|---------|----------|----------|----------|---------|
| Numbu     | 262.67  | 130.00   | 146.67   | 182.67   | 180.50  |
| Super 1   | 259.33  | 315.00   | 406.33   | 604.33   | 396.25  |
| Suri 3    | 214.33  | 114.67   | 129.00   | 75.33    | 133.33  |
| Keller    | 290.67  | 521.33   | 307.67   | 394.33   | 378.50  |
| Kawali    | 147.00  | 119.00   | 100.33   | 146.33   | 128.17  |
| Average   | 234.80 a| 240.00 a | 218.00 a | 280.60 a |         |

Description: a number followed by the same letter in a row or column showed no significant in Duncan test 5%

Table 6 shows that the treatment on the number of 4 shoots produced the highest yield per plant. A large number of shoots would form a large number of panicles. The more panicles, the more grains of sorghum grains so then it can increase crop yields per plot.

Super-1 which was developed from a pure line selection of the local variety Watar Hammu Putih from Sumba, East Nusa Tenggara and Super-2 which was developed from the introduced line ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) is a sweet sorghum variety with high yield potential. grain reaches 6 t/ha and the potential sap content is more than 17% brix scale. Suri 3 has morphological characteristics such as compact panicle, symmetrical panicle shape, dark brown husk color, reddish brown grain color, difficult to fall off grains, very few, pithy, long grains, and single grain, flat shape [19].

Figure 2. Sorghum Super-1 varieties (a) and sorghum Suri 3 varieties (b)

4. Conclusion
The results discovered that the highest plant in the Numbu variety, while the largest stem diameter was in the Kawali variety. The treatment of 4 shoots increased the grain yield per clump however it decreased the plant height compared to the number of shoots that were less. The yield of grains per plot was higher
for Super 1 varieties as much 604.33 g or 3.3 ton/ha, however the highest number of grains per clump was on Kawali varieties. In addition, there was no interaction between the varietal treatment and the number of shoots for all observation variables.

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