

Effect of irrigation methods and testing some rice cultivars against growth, root development and yield on rainfed Ultisols of Aceh Besar

H Helmi¹, S Zakaria², Efendi³, A A Munawar³ and R Aulia⁴

¹Program Study of Soil Science, Faculty of Agriculture, Universitas Syiah Kuala, Darussalam-Banda Aceh 23111
²Program Study of Agrotechnology, Faculty of Agriculture, Universitas Syiah Kuala, Darussalam-Banda Aceh 23111
³Program Study of Agriculture Engineering, Faculty of Agriculture, Universitas Syiah Kuala, Darussalam-Banda Aceh 23111
⁴Office of Agriculture and Food Service of Aceh Besar District, Kota Janto 23918

*Email: helmi@unsyiah.ac.id

Abstract: The main obstacle in rice cultivation on dryland is the limitation of water availability and large fluctuation of groundwater availability. It causes plant metabolic processes to be hampered. The threat of such natural conditions can be overcome by intensifying and using superior cultivars to adapt widely to the environment, such as being resistant to drought. This study aims to determine the effect of irrigation methods and the response of several different cultivars to growth, yield potential, and rice root systems. This research using a Split Plot Design pattern. The factors examined in this study were irrigation methods, which consisted of 3 levels of treatment, namely continuous irrigation (P1), intermittent irrigation (P2), and sprinkler irrigation (P3). Variety factors consisted of 4 levels, namely: Batutegi (V1), Situ Patenggang (V2), Inpago 5 (V3), and Sanbei (V4), so there were 12 treatment combinations with three repetitions of 36 treatment plot units. The results showed that the continuous and intermittent irrigation methods gave the highest yield per hectare and had the same weight, while the sprinkler gave the lowest yield per hectare, although not significantly different from other irrigation methods. The cultivar that gave the highest yield per hectare was Sanbei, while the lowest was Situ Patenggang, and the cultivar that gave the highest 1000 grain weight was Inpago-5, while the lowest was Sanbei, although it was not significantly different from other cultivars.

1. Introduction

Rice (Oryza sativa L.) is the main food crop of Indonesian society, but rice availability is still low to meet the needs of the Indonesian population. To maintain their survival, humans try to meet their primary needs, namely food. Along with the high rate of population growth, the need for rice is also increasing. Indonesia's assumed consumption reached 139.15 kg per capita, higher than the world's average 60 kg per capita. Therefore, rice availability is very important, including the system in increasing the potential yield [1]. The increase in population is closely related to the increasing need for rice production. To intensify rice cultivation, it is necessary to improve the production system of rice production to increase rice availability especially in Aceh region.
for food so that it has the potential to increase the amount of food demand, especially rice. Meanwhile, this is not balanced with fertile land to increase the potential for agricultural products. One of the efforts is to expand the land by utilizing dry land using rice cultivar that is resistant to drought stress. Indonesia has dry land with an area of more than 55.6 million ha [2].

The vast potential of Indonesia's dry land has not been optimally utilized. It tends not to receive serious attention, in addition to the potential for the wide availability of dry land. The main obstacle in cultivation on dry land is the availability of very little water and large groundwater content fluctuations. Though it causes all plant metabolic processes to be hampered in developing rice will be faced with low water availability [3]. This condition is also exacerbated by the presence of climate anomalies that cause drought so that primary water sources (rain) are limited [4]. The threat of such natural conditions can still be overcome by intensifying and using superior cultivars to adapt widely to the environment, such as being resistant to drought. The consequences of water shortages are thought to reduce rice yields because the planting area is reduced and crop needs are not met.

The need of water for a season rice planting ranges from 590-760 mm. Meanwhile, the daily water requirement for rice that is early maturing and long-lived reaches a maximum in the reproductive phase, which is between the flowering phase and 50% grain filling reaches 8.0 - 8.8 mm.day⁻¹, then decreases in the ripening phase to 7.3 - 7.6 mm.day⁻¹. The longer the drought period and the more uncertain the seasons indicate the importance of efforts to make efficient use of water, as one of the main resources for plant life's physiological processes. The provision of irrigation water to agricultural land aims to meet the needs of plant water to grow optimally; however, the uncertainty of water availability is a major problem at present. This case is one of the consequences of global climate change that affects rice irrigation [5]. Climate change impacts have caused drought, which has caused crop failure and decreased rice production. The average water uses for one rice-growing season ranges from 900 - 2,250 mm, the average water use for lowland rice reaches 1,300-1,900 mm, where 25-50% of this amount is lost due to percolation and seepage. The rice cultivation system in paddy fields requires a lot of water availability. Continuous inundation conditions during the rice growth cycle require a continuous supply of sufficient water and limit non-aquatic weeds' growth. Effective and efficient water management techniques determine the amount of water needed for a one-time potential rice yield [6].

Water management for potential crop products must pay attention to the soil's physical and chemical properties, weather conditions, plant types (cultivar), water availability, and Irrigation Methods. Water management to anticipate water scarcity can be carried out by regulating Irrigation Methods and cultivar because it relates to water needs for potential crop yields [7]. Research on water consumption in rice and its efficiency is important because water availability is increasingly limited as an important factor for potential rice yields. Information on rice plants' water requirements is needed for researchers and farmers in selecting rice cultivars that can adapt well to water shortages. Lack of water will interfere with physiological and morphological activities, resulting in the stoppage of growth. These problems can be overcome by managing the use of irrigation water properly and efficiently. The volume of water consumption in several rice genotypes had shown increased yields by intermittent method and the occurrence of water savings of around 27.8% [8]. From these problems, it is necessary to research to determine the effect of different irrigation methods on the root development system to obtain maximum growth and yield potential of some rice cultivar on rainfed ultisol of Aceh Besar.

2. Materials and methods

2.1. Materials

The materials used in this study was seed that consisted of 4 (four) rice cultivar, namely the national cultivar Batutegi, Situ Patenggang, Inpago 5, and local cultivar Sanbei. Other materials used were polybags size 35 cm x 35 cm. The basic fertilizer to be used in this research is NPK Phonska. The tools used in this research include 2 and ¾ inch diameter PVC pipe, 90° elbow, coroplast glue,
analytical scales, gauges, and digital cameras. This research was implemented on a rainfed rice field, Jantho village, Aceh Besar District, located at an altitude of ± 250 - 300 m above sea level, and the soil type is Ultisol. The results of the analysis of soil samples at the research location indicate that the fertility level is low. It is characterized by a pH of 6.5. The content and availability of nutrients are relatively low which is indicated by moderate available P, low total C and N content and medium cation exchange capacity (CEC), Ca and Mg content, while high Na content. The initial soil characteristics at the research location can be seen in Table 1, and the total rainfall, temperature, humidity in the study area can be seen in Table 2.

### Table 1. Characteristics of the soil used in the experiment.

| Parameters                       | Unit      | Value | Level*     |
|----------------------------------|-----------|-------|------------|
| pH H₂O (1:1)                     |           | 6.50  | Little Acid|
| Organic carbon                   | g kg⁻¹    | 1.67  | Low        |
| Total-N                          | g kg⁻¹    | 0.19  | Low        |
| Available-P (Bray I)             | mg kg⁻¹   | 8.80  | Medium     |
| Exchangeable- K                  | cmol(+) kg⁻¹ | 0.60 | Sedang     |
| Na                               | cmol(+) kg⁻¹ | 0.84 | High       |
| Ca                               | cmol(+) kg⁻¹ | 5.94 | Low        |
| Mg                               | cmol(+) kg⁻¹ | 0.66 | low        |
| Cation exchange capacity         | cmol(+) kg⁻¹ | 23.00 | Medium     |
| Texture: Sand                    | %         | 38.00 | Clay sandy |
| Dust                             | %         | 17.00 |            |
| Clay                             | %         | 45.00 |            |
| Soil water content               | %         | 1.80  | Low        |

Note: * Based on the criteria of soil characteristics proposed by Soil Research Institute (1983)
Source: Laboratory of soil chemistry, Faculty of Chemistry, Universitas Syiah Kuala (2020)

### Table 2. Monthly Rainfall, humidity, temperature and humidity in study area

| Month & year | Rainfall | Temperature | Humidity |
|--------------|----------|-------------|----------|
| November 2019| 270.5    | 26.2        | 88       |
| December 2019| 320.5    | 26.0        | 89       |
| January 2020 | 285.5    | 26.3        | 84       |
| February 2020| 66.5     | 26.0        | 81       |
| March 2020   | 116.0    | 26.7        | 82       |
| April 2020   | 364.0    | 26.4        | 86       |

Source: BMKG Climatology Station Class-IV, Indrapuri (2020)

2.2. Methods

This study used a Split Plot Design pattern consisting of two factors: the irrigation methods factor consisting of three levels, the irrigation method factor placed in the main plot. Variety factors that were tested consisted of four levels placed in subplots. The Irrigation factor (P) as the main plot consists of 3 levels: P1 = Continue irrigation; P2 = Intermittent irrigation; P3 = Sprinkler irrigation. The Continue irrigation treatment was carried out by irrigating rice plants as high as 3 cm from the soil surface from transplanting until the flowering age was complete. Intermittent irrigation was done by irrigating rice plants as high as 3 cm intermittently at intervals of 10 days inundation and 10 days of wet drying from transplanting until flowering is complete. Irrigation sprinkler treatment is carried out by spraying water through ¾ inch PVC pipe which is given a 1 mm diameter hole with rarely 10 cm
holes, irrigation is carried out every day for 2 hours until the wet soil reaches a field capacity condition. Cultivar factor treatments (V) as a sub-plot consisting of 4 levels: V1 = Batutegi; V2 = Situ Patenggang; V3 = Inpago 5; and V4 = Sanbei. Thus there are 12 treatment combinations. The experiment is repeated three replications so that there are 36 experimental units. The parameters observed in this study were plant height at 7 WAP, number of productive tillers, flowering age, weight of 1000 grains of grain, yield per hectare and weight of dry roots.

3. Results and discussion

3.1. Effect of irrigation methods

The variance analysis results due to irrigation method treatment of plant height, number of productive tillers, flowering age, the weight of 1000 grains of grain, yield per hectare, and dry weight of rice roots can be seen in Table 3.

| Irrigation Methods | Plant height 7 WAP (cm) | Amount of tillers (tiller) | Flowering ages (day) | Weight 1000 grains (gram) | Yield (ton/ha) | Dry weight of roots (gram) |
|-------------------|------------------------|---------------------------|----------------------|---------------------------|---------------|---------------------------|
| Continue          | 99.45                  | 12.59                     | 65.64                | 26.21                     | 4.96          | 471.81c                   |
| Intermitten       | 100.77                 | 11.85                     | 64.58                | 26.24                     | 4.96          | 384.36a                   |
| Sprinkler         | 101.96                 | 11.83                     | 68.17                | 26.11                     | 4.74          | 378.83ab                  |
| LSD 0.05          | -                      | -                         | -                    | -                         | -             | 45.64                     |

3.1.1. Plant height.

The highest plant height was found in the sprinkler irrigation method treatment, although it was not significantly different from other irrigation methods. This case is presumably because each rice plant water need is determined by several factors such as soil type, soil fertility, climate (wet or dry), plant age, and cultivar of rice being planted, and so on. Provision of water with different watering volumes is not a driving variable or a factor that increases rice plants’ growth. The ability to absorb the same water in rice plants causes the same growth even though it is given water with different watering volumes. The treatment of water provision based on the calculation of the given field capacity is the amount of water absorbed and retained by the soil. Even though there is sufficient water available in the soil, it does not mean that plants will absorb all the water. This condition is what probably causes the growth of rice plants in each of the given treatments. Plant height growth is getting better with high soil moisture. The high growth and yield in soil moisture content above field capacity is due to good root development, so that the absorption of nutrients, water, and oxygen causes plant growth and yields also to increase [9].

3.1.2. Number of productive tillers and flowering age

The highest number of productive tillers was found in the continuous irrigation method treatment, although statistically, it did not significantly differ with other treatments. Irrigation conditions do not affect many tillers per clump of rice plants; it is because the treatment of irrigation conditions is optimal enough to provide a conducive atmosphere for evenly grown tillers. After all, the growth environment is not flooded during the vegetative growth phase [10]. The existence of wetting and drying cycles in the wet treatment regime can increase soil aeration so that the oxygen supply to the roots is sufficient to increase the activity of microorganisms and the absorption of nutrients used to
form tillers and grain formation. It is possible that in these conditions, the plant responds by increasing the length of the stems to help meet the needs of oxygen and carbon dioxide to support aerobic respiration and photosynthesis so that the growth of the number of tillers is increasing.

The lowest flowering age was found in the intermittent irrigation method, although statistically, it did not significantly differ with other treatments. Furthermore, the irrigation conditions did not produce significantly different flower times, but the irrigation conditions using sprinklers tended to produce a longer flowering life than treatments with other irrigation conditions. The insignificant effect on flowering age was due to the already effective irrigation conditions, which gave the same effect to all treatments; presumably, the use of water provided had met the plants' water needs. When the number of tillers per hill was not significantly different, the plant needed the same number of assimilates. Still, when the number of tillers died in the vegetative period, there was a difference in the use of assimilates. This situation can push the difference to the generative period. Different flowering ages are in the diverse vegetative phase. The transition between the vegetative phase to the generative phase is indicated by the beginning of the rice plant's flowering. If 75% of the plants in one flower bed have come out, then the plant is considered to have entered the flowering phase. The insignificant effect on flowering age was caused by effective irrigation, which affected all treatments [11].

3.1.3. Weight of 1000 grain and yield per hectare
The highest weight of 1000 grains was found in the intermittent irrigation method, although it did not significantly differ from other irrigation methods. This case is thought to be caused by intermittent irrigation water provision and left when the soil is still inundated until it dries up. Differences in water requirements can accelerate flowering, resulting in different results. Each rice line that flowered faster gave a better yield than the slower flowering line. The response of drought stress to the number of grains per hill for each cultivar is different. When related to the flowering age, plants with a faster flowering age would experience a slower decline in the number of grains per clump than those with a longer flowering. The longer the flowering period, the lower the rice plants' yield. Yield capacity can be increased without overgrowth because overgrowth causes a reduced supply of assimilates, causing the resulting number of grains to be hollow [12].

Attempts to provide water for agricultural purposes and giving is carried out in an orderly and regular manner to agricultural areas that need it. After use, the water is discharged to the drainage channel in an orderly and regular manner. Irrigation aims to add water to the soil to provide the necessary fluid for plant growth, cool the soil and the atmosphere, creating a favorable environment for plant growth. The combination of wetting and drying in the soil could increase aeration between the soil and the atmosphere. The oxygen supplied to the root system is sufficient to produce nutrients essential to support rice growth. Besides, the number of productive tillers per hill also affects grain production. When photosynthate is used more for the growth and development of rice plants in each variety's vegetative period, it will affect the length of the panicles that will be formed [13].

3.1.4. Weight of dry root
The highest dry root weight was found in continuous irrigation treatment, while the lowest root dry weight was found in the sprinkler irrigation method treatment. It is assumed that the allometry of canopy growth and root growth has a physiological relationship. Dry root weight can describe one type of tolerance to drought. The size of a plant's dry root weight is controlled by genetic and environmental factors. When the plant is short of water, the plant will extend its roots to the soil layer with sufficient water availability so that the plant can survive. Long-rooted plants will better absorb water than short-rooted plants [14].

Aerobic conditions support root growth and development through the provision of adequate oxygen. Changing the distribution of new assimilates will support root growth rather than the crown, thereby increasing the roots' capacity to absorb water and inhibit crown growth from reducing transpiration. Adjusting the degree of opening of the stomata will inhibit water loss through transpiration. The low growth and yield in the soil water content below the field capacity are due to
poor root development. The absorption of nutrients, water, and oxygen are not enough, causing the upper and crop yields to decrease. The canopy growth is encouraged if there is much nitrogen (N) and water available, whereas root growth is more promoted when nitrogen and water factors are limited. This case will affect the canopy root ratio; the root canopy ratio is used to determine plants' ability to maintain functional balance in stressful environments. The canopy-root ratio is plastic; its value will increase underwater availability, nitrogen, oxygen, and low temperatures [15]. This condition happens because stressed plants will allocate most of the photosynthesis results in the storage organs.

In times of water shortage, root system growth generally increases, while crown growth decreases. Plants that are more concerned with root growth than canopy growth will better withstand water deficiency conditions. The root canopy ratio is the ratio between crown growth and root growth. The magnitude of the canopy root ratio is related to plants' increased water absorption capacity as a mechanism to maintain high water potential when plants experience water shortages. The ability of roots to absorb water by maximizing the root system is one of the main approaches used to see the adaptability of plants to water shortages. Under the normal conditions, rice roots grow slightly compact, and horizontal root distribution is more dominant than perpendicular to the soil. The average ratio of shallow root weight to the heaviest deep root weight found in sprinkler irrigation can provide an opportunity for oxygen to enter the soil because there is no inundation. This condition can help increase aerobic microorganisms' activity, which will increase the rate of decomposition of organic matter, which means that it will increase the nutrients available to plants [16].

The role of roots in absorbing groundwater during growth determines the smooth process of photosynthesis in producing grain. In dry climates, the role of roots is considered very important because the absorption of groundwater depends on the roots' ability to penetrate deeper into the soil layer. Roots that are deep and thick, healthy, grip the soil wider, and are strong enough to hold the laying down allows for more efficient absorption of water and nutrients, especially during the grain filling stage. The correlation coefficient results show that there is a very significant positive relationship between root dry weight and grain weight per clump occurs in sprinkler irrigation conditions, and the highest relationship occurs when the cultivar is broken.

The higher the cultivar dry root weight, the yield clumps increased by 48.80%. Increasing the roots' volume will affect the absorption of water and nutrients, including the element N, resulting in the dry weight of straw and leaf area. The plant combination factor affects the dry weight of the roots. This case is presumably, to maintain the status of water in the soil, that is, by maintaining the development of root size to absorb water, which will affect the root weight. The role of roots in absorbing groundwater during growth determines the photosynthesis process's smoothness. Increasing the photosynthetic process can produce higher photosynthate, which can increase the production of root dry weight [17].

### 3.2. Effect of rice cultivars

The results of the variance analysis due to cultivar treatment on plant height, number of productive tillers, flowering age, the weight of 1000 grains of grain, yield per hectare, and dry weight of rice roots can be seen in Table 4.

| Cultivars | Plant height 7 WAP. (cm) | Amount of tillers (tiller) | Flowering ages (day) | Weight 1000 grains (gram) | Yield (ton/ha) | Dry weight of Roots (gram) |
|-----------|-------------------------|--------------------------|----------------------|--------------------------|---------------|--------------------------|
| Batutegi  | 110.15 c                | 11.72                    | 68.74b               | 24.36 b                  | 4.84          | 439.15 b                 |
| Situ      | 100.51 b                | 11.01                    | 63.89c               | 27.83 c                  | 4.74          | 493.52 c                 |
3.2.1. **Plant height**

The highest plant height was found in batutegi cultivars, which were significantly different from other cultivars. This condition is thought to be caused by the influence of a set of traits called genes. Even though the basic constituents are the same, each cultivar has different levels of genetic diversity, both genetic levels in plant height, plant production, that causing variations between individuals that their genetics including plant height influences each cultivar plants [18].

3.2.2. **Number of productive tillers and flowering age**

Differences in cultivar types did not show significant differences in the number of productive tillers, while the flowering age was significantly different due to cultivar treatment. The highest number of tillers was found in Sanbei cultivars, while the fastest flowering age was found in Inpago 5 cultivars. The difference in each cultivar's genetic characteristics is different, including in terms of plant adaptation to the limited availability of water, so there are various responses. Plant height and number of productive tillers were strongly influenced by cultivars and lines that had better adaptation to the environment. This condition is due to differences in the characteristics and special traits of the cultivar's genetic makeup. Genetic makeup differences are one of the causes of diversity in plant appearance. Genetic programs are expressed in various plant traits that include plants' form and function that produce diversity. This case is presumably because each cultivar has different abilities in producing the maximum number of tillers with different irrigation conditions, resulting in competition between plants both in nutrients [19].

3.2.3. **Weight 1000 grain and yield per hectare**

The highest grain weight of 1000 grains was found in Inpago 5 cultivar, which was significantly different from other cultivars, while the highest yield per hectare was found in Sanbei cultivar, although it was not significantly different from other cultivars. It is assumed that Inpago 5 grain is pithier than other cultivars, while the Sanbei cultivar has a higher number of productive tillers than other cultivars, causing the yield to increase. The number of productive tillers was positively correlated with the yield, while the number of filled grains and the total number of grains were also positively correlated. Superior cultivars are capable of high yields because they have morphophysiological characters following the growing environment to produce optimal physiological processes. The amount of grain is determined by plant genetic characteristics, especially panicle length, panicle branch, and grain differentiation. This condition is because rice plants' ability to produce panicles is much influenced by genetic factors or the plant's characteristics; the longer the panicles and the higher the yield obtained [20].

3.2.4. **Weight of dry root**

The highest root dry weight was found in Sanbei cultivars, although it was not significantly different from other cultivars. The decreased biomass accumulation due to lack of water for each type of plant varies depending on each type of plant's response to water shortages. The number, length, and diameter of the transport bundles, especially xylem, strongly determines the capacity of rice roots, which is better when interrupted irrigation can improve water and nutrient transportation from the soil to the trunk so that it will support better canopy growth. A good canopy growth will cause many available photosynthates so that the photosynthesize is distributed to the roots so that the roots grow optimally. High root permeability can improve water absorption in tougher soils. Root penetration indicates the ability of the roots to penetrate the soil layer. The soil layer is getting deeper and harder.

### Table

| Cultivar   | Plant Height (cm) | Number of Tillers | Flowering Age (d) | Grain Weight (g/kg) | Yield per Hectare (t/ha) |
|------------|-------------------|-------------------|-------------------|---------------------|--------------------------|
| Inpago 5   | 12.44             | 59.62c            | 28.84 d           | 4.82                | 441.41 b                 |
| Sanbei     | 13.19             | 72.26a            | 23.71 a           | 5.14                | 377.89 a                 |
| BNT 0.05   | 3.73              | 0.61              | -                 | -                   | 39.64                    |

7
It will affect root growth and absorption of water and nutrient elements; rice plant roots will try to lengthen their roots and penetrate the layer to find water. The amount of root penetration in the hard soil layers can increase water absorption in the deeper soil layers. Plants with large root volumes will be able to absorb more water to survive conditions of water shortages. Plants that develop deep root systems can extract water in deeper soil layers, such as patchouli, which extends its roots to search for water [21-24].

4. Conclusions

The irrigation method's treatment did not give significantly different results on the height of rice plants, the number of tillers, flowering age, the weight of 1000 grains of grain, and yield per hectare, but significantly different on root dry weight. The continuous and intermittent irrigation method gave the highest yield per hectare, and the weight was the same, while the sprinkler irrigation method gave the lowest yield per hectare, although not significantly different from other irrigation methods. Cultivar treatment gave significantly different results on plant height, flowering age, the weight of 1000 grain of grain, and root dry weight, but not significantly different on the number of productive tillers and yield per hectare. The cultivar with the highest yield per hectare was Sanbei, while the lowest was Situ Patenggang although it was not significantly different from other cultivars. The cultivar that gave the highest 1000 grain weight was Inpago-5, while the lowest was Sanbei, although it was not significantly different from other cultivars.

References

[1] Humaedah U, Sundari, Astuti S, Trisedyowati Y. 2010. Farming with PTT approach. Center for Agricultural Extension Development, Jakarta.
[2] Ar-Riza, L., 2002. Applicative Technology of Rice Yield Potential in Dry Wet Climate. Proceedings of the National Seminar on Dry Land and Swamp Agriculture. Banjar Baru. 18-19 December 2002.
[3] Noor, M., 1996. Marginal Land Rice. Self-Help Spreader. Jakarta. 15 p.
[4] Setiobudi D, Abdullah B, Sembiring H, and Wardana IP. 2008. Increasing Yield of New Types of Rice by Managing Nitrogen Fertilizers. Proceedings of Symposium V on Food Crops - Food Crop Technology Innovation. Research and Development Center for Food Crops, Agricultural Research, and Development Agency. Vol 2: 345-353.
[5] Da Silva, J., S. Kernaghan., And A. Luque. 2012. A systems approach to meeting the challenges of urban climate change. International Journal of Urban Sustainable Development, 4 (2): 125-145.
[6] Bouman B.A.M., Yang X, Wang H, Wang Z, Zhao J, Chen B. 2007. Performance of aerobic rice varieties under irrigated conditions in North China. Field Crops Res 97: 53–65.
[7] Mati BM, 2012. Benefit-cost analysis of paddy rice under the system of rice intensification in Mweea. Kenya.
[8] Hakim N, Nyakpa MY, Lubis AM, Nugroho SG, Saul MR, Diha MA, Hong GB and Bailey HH. 1986. Basics of Soil Science. Lampung University. Lampung.
[9] Zen, S, Daswal, and H. Bahar. 2000. Diversity of Potential Strains. Specific Reference. West Sumatra. Proceedings of the National Seminar on Food Security and Agribusiness, 21-22 November 2000. Food Crops Research Institute. Sukarami. Padang. Pp. 22-25.
[10] Palupi ER, Dedywiryanto Y. 2008. Study of drought tolerance character in four genotypes of oil palm seedlings (Elaeis guineensis Jacq). Bul Agron 36 (1): 24-32.
[11] Wangiyana, W., Laiwan, Z., and Sanisah. (, 2006). Growth and yield of rice under "Sri (system of rice intensification)" technique at various ages and numbers of seedlings per hill. Scientific Journal of Agricultural Crop Agronomy 2 (1), 70-78.
[12] Taslim, H., S. Partohardjono, and Djunainah. 1993. Rice Cultivation. In. Ismunadjji, et al. (Eds). Rice Book 2. Research Center and Food Crop Development. Bogor. h. 481-505.

[13] Ismunadjji M, Manurung SO. 1988. Paddy Book I. Agricultural Research and Development Agency. Agricultural Research and Development Center. Bogor. Pp. 55-102.

[14] Shao, G.C., S. Deng., N. Liu., SE Yu., M.H. Wang., And DG She. 2014. Effects of controlled irrigation and drainage on growth, grain yield, and water use in paddy rice. European Journal of Agronomy Vol. 53: 1-9.

[15] Fitter and Hay. 1991. Environmental Physiology of Plants. Gajah Mada University Press. Yogyakarta.

[16] Lin, X., D. Zhu, & X., Lin. 2011. Effects of water management and organic fertilization with SRI crop practices on hybrid rice performance and rhizosphere dynamics. Paddy Water Environ, 9: 33–39.

[17] Suardi D (2002) Rice rooting concerning plant tolerance to drought and yield. Journal of Agricultural Research and Development 21 (3): 100-108

[18] Abdullah B, Mudjisihono R, Prajitno. 2006. Several Genotypes of Rice Toward Improvement of Rice Quality. Researcher of the Sukamandi Rice Research Center. 5 p.

[19] Rahayu AY, and Harjosito T. 2011. Application of Husk Ash on Rice (Oryza sativa L.) on Silicate and Proline Content of Leaves and Amylose and Seed Protein. Faculty of Agriculture, Jenderal Soedirman University. Biota Vol. 16 (1): 48-55.

[20] Bakhtiar, BS. Purwoko, Trikoesoemaningtyas, and IS Goddess. 2010. Correlation analysis and cross coefficient between several upland rice characteristics on acid soil media. J. Floratek 5 (2): 86 - 93.

[21] Djazuli, M., 2010. Effect of drought stress on growth and Some Patchouli Plant Morpho-Physiological Characters. The Littro Bulletin. 21 (1): 10-12.

[22] Darusman D, Juwita I R, Munawar A A, Zainabun Z and Zulfahirzaal Z 2021 Rapid determination of mixed soil and biochar properties using a shortwave near infrared spectroscopy approach IOP Conf. Ser. Earth Environ. Sci. 667

[23] Munawar A A and Sabaruddiin Z 2021 Fast classification of rice (Oryza sativa) cultivars based on fragrance and environmental origins by means of near infrared spectroscopy IOP Conf. Ser. Earth Environ. Sci. 644 012003

[24] Helmi H, Munawar A A, Bakhtiar B and Zulfahmi Z 2021 Comparisons among soil tillage system and their impacts to the tested rice varieties on lowland rainfed alluvial in aceh jaya Food Res. 5 173–8