Adaption of local rice cultivars Banten to drought environment

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Abstract. Limited water availability or drought is an abiotic factor that inhibited rice production. One of the efforts to overcome this problem is by using plant varieties that can adapt to conditions of limited water availability. This study aims to determine the physiological and agronomic responses of some local rice cultivation in South Banten to drought conditions. The research was conducted from April to October 2017 in the greenhouse of the Faculty of Agriculture, Sultan Ageng Tirtayasa University, Banten. The experiment was based on factorial experiments in a completely randomized block design (RBD) with 3 replications. The first factor is the frequency of irrigation which consists of 2 levels, namely irrigation every 7 days and every 9 days. The second factor is the local rice cultivar in South Banten which consists of 8 levels, each of which consists of 7 local cultivars and one comparison variety, namely Ren cong, Ketan Dewo, Kiara, Inpari 10 (as comparison varieties), Super, Kapundung, Cimoherang, and Ketan Elfi. The results of research show that cultivar of Ketan Dewo adaptive in drought environments.

1. Introduction
Food needs, especially rice, will continue to increase in the future in line with the increasing population of Indonesia and the world. Rice self-sufficiency is very important considering that this commodity is a staple food and tends to be single in various regions in Indonesia, including areas that previously had a pattern of staple food not rice [1]. Currently, there is a decrease in rice production caused by the drought. The impact of extreme climate change in the form of drought ranks as the first cause of crop failure. This condition has implications for the decline in production and farmer welfare [2].

Drought stress before affecting the morphology of plant growth and yield, first results in dehydration and decreases the turgor pressure of plant cells, thereby stimulating stomata closure, inhibiting CO2 diffusion, and photosynthesis [13]. The results of the research by [3] showed that drought stress significantly reduced plant height, number of leaves, number of tillers, panicle length, 1,000 grain weight, crown dry weight, and harvest index, and increased the percentage of empty grain, but the interaction between drought and variety had no significant effect. The interaction of dry
periods and varieties significantly affected the number of productive tillers, the percentage of flowering, and the weight of grain per hill.

In an effort to reduce or eliminate the impact of climate change on food crop production, [4] and [5] suggest crop diversification, crop rotation, and the application of production enhancement technologies. One of the applications of increasing productivity technology can be done by obtaining and providing rice seeds that are drought tolerant.

[6] state that proline accumulation can be used as an indicator of drought tolerance. Protein accumulation in dehydration conditions is caused by proline biosynthetic activity and proline degradation inactivity. The osmoprotectant compound proline, glycine betaine, and another osmoticum can be used to differentiate the tolerance level of plants to drought stress. Plants that have a higher osmoticum increase are thought to be more tolerant than plants with a lower osmotic increase. Leaf proline levels tend to increase with decreasing groundwater availability experienced by plants [7] [8] [14].

The diversity of local rice cultivars in the South Banten region is a source of selection material for obtaining drought-tolerant rice plants. Local rice cultivars are rice varieties that have long adapted to an area that has certain advantages and disadvantages so that the rice has different characteristics in each region. In general, the weaknesses of local cultivar rice include long life, low yield potential, however, it has several superior properties including resistance to pests and diseases and very adaptive to marginal environments including drought conditions.

The use of plants that are responsive to climate change, consumption and efficient use of water, and exploring related mechanisms are effective means for the security of food sources in the future [9]. Therefore, one of the efforts to overcome the decline in production due to drought is to obtain drought-tolerant rice seeds (rice plants) through a series of selection stages is very important. This study aims to determine the physiological and agronomic responses of several local rice cultivars from South Banten to drought.

2. Research Methods
The research was conducted from April to October 2017 in the greenhouse of the Faculty of Agriculture, University of Sultan Ageng Tirtayasa, Banten. Data obtained from observations in each experimental unit. To obtain drought tolerant cultivars (physiological and agronomic characters), a factorial experiment was carried out in a randomized block design with 3 replications. The first factor is the frequency of irrigation (F) which consists of 2 levels, namely: Irrigation once every 7 days (f1) and once every 9 days (f2). The second factor is local rice cultivars from South Banten consisting of 8 levels including 7 local cultivars and one comparison variety, respectively: Rencong (k1), Ketan Dewo (k2), Kiara (k3), Inpari 10 (k4) as comparison varieties, Super (k5), Kapundung (k6), Cimoherang (k7), and Ketan Elfi (k8). The tools used are buckets, meters, analytical scales, ovens, and a set of prolin analysis tools and materials. Materials let alone rice seeds what are the basic fertilizers (N, P, and K) and water. The variables observed included plant height, leaf width, number of tillers, leaf proline content, number of panicles per plant, and weight of harvested dry grain. Drought tolerance is quantified based on the definition of drought tolerant plants as plants that can maintain production in drought stress conditions [13].

The experiment was started with the preparation of the planting medium (taking the paddy soil and then lubricating it) and placing it in a bucket of 8 kg per bucket as an experimental unit. The irrigation treatment was started 4 weeks after planting by irrigating all experimental units until an inundation height of 2.5 cm. Irrigation was carried out according to treatment until the water level returned to a height of 2.5 cm. Data were analyzed using SPSS version 20 for analysis of variance and comparison test between treatments with the Duncan Multiple Range Test (DMRT).
3. Results and Discussion

3.1 Plant Height, Leaf Width, and Number of Panicles

Based on the analysis of the variety of data on plant height, leaf width, and the number of panicles per plant, there were no differences due to different irrigation frequencies, both irrigation every 7 days and irrigation every 9 days. The differences in plant height, leaf width, and number of panicles per plant were shown to be due to differences in cultivars planted (Table 1).

Table 1. Average plant height, leaf width, and panicle number of local rice cultivars from South Banten with different irrigation frequencies

| Local Cultivar Rice Origin Banten | Plant height (cm) | Leaf width (cm) | Number of panicles |
|----------------------------------|-------------------|----------------|-------------------|
| Rencong (k₁)                     | 85.87b            | 1.42b          | 19.3ab            |
| Ketan Dewo (k₂)                  | 76.30b            | 1.18bc         | 18.3b             |
| Kiara (k₃)                       | 107.43a           | 1.22bc         | 24.6a             |
| Inpari 10 (k₄)                   | 53.83a            | 1.00c          | 20.0ab            |
| Super (k₅)                       | 108.00 a          | 1.77a          | 5.0c              |
| Kapundung (k₆)                   | 77.42d            | 1.13bc         | 8.2c              |
| Cimoherang (k₇)                  | 63.92cd           | 0.95c          | 14.2b             |
| Ketan Elfi (k₈)                  | 73.67bc           | 1.07bc         | 14.0b             |

Note: The numbers followed by the same lowercase letter in the same column show no difference according to the DMRT test at the 5% level, * national varieties (comparison)

The plant height of the seven local rice cultivars from South Banten, six cultivars were higher than the comparison variety (Inpari 10) and one cultivar was the same height as Inpari 10. The height of the local rice cultivars from South Banten could be classified into three classes, namely: short (Cimoherang) is the same as Inpari 10; medium (Ketan Elfi, Ketan Dewo, Kapundung, and Rencong; and high (Kiara and Super).

The leaf widths of the seven local cultivars from South Banten varied and could be classified into three classes, namely: having the same leaf width as Inpari 10, namely Ketan Dewo, Kiara, Kapundung, Cimoherang, and Ketan Elfi; leaf width wider than Inpari 10 namely Rencong; and the widest is the Super cultivar.

The number of panicles per plant of the seven local cultivars from South Banten varied and could be classified into three classes, namely: having the least number of panicles per plant (Kapundung and Super cultivars); the moderate number of panicles per plant (Ketan Dewo, Cimoherang, and Ketan Elfi cultivars); and a large number of panicles per plant (Kiara and Rencong cultivars) including the Inpari 10 variety as a comparison.

The differences in plant height, leaf width, and the number of panicles per plant of the seven local rice cultivars from South Banten can be understood because the genes of plant height, leaf width, and the number of panicles per plant are thought to be inherited traits and a source of variation among cultivars planted. According to [10] genetic variance together with environmental variance and interaction variance between genetic-environment are the determining factors for the appearance of a character. The selection of a character based on the phenotype will only be useful if the variation in the character is a reflection of genetic variation, so that the selection provides considerable genetic progress. The existence of wide genetic variability for certain characters allows for effective selection that will be useful in plant development by concentrating good characters in one plant cultivar [11].

3.2. Number of Tillers

Based on the results of data analysis, the number of tillers per plant showed differences due to different irrigation frequencies and due to different cultivars planted. However, there was no difference in the number of tillers due to the interaction between irrigation frequency and cultivars.
The average number of tillers per local rice cultivar plant from South Banten with different irrigation frequencies is presented in Table 2.

**Table 2.** The average number of tillers of local cultivar rice from Banten with different irrigation frequencies

| Local Cultivar Rice Origin Banten | Frequency of Water Supply (days) | Average |
|----------------------------------|---------------------------------|---------|
|                                  | 7                               | 9       |
|                                  | ...................................(tillers)............................................... |
| Rencong (k₁)                     | 15.0                            | 13.7    | 14.3cd |
| Ketan Dewo (k₂)                  | 20.7                            | 17.3    | 19.0b  |
| Kiara (k₃)                       | 16.7                            | 10.3    | 13.5cd |
| Inpari 10 (k₄)*                  | 15.0                            | 11.3    | 13.2bcd|
| Super (k₅)                       | 3.0                             | 3.7     | 3.3e   |
| Kapundung (k₆)                   | 11.3                            | 9.7     | 10.5d  |
| Cimoherang (k₇)                  | 14.0                            | 16.7    | 15.3bc |
| Ketan Elfi (k₈)                  | 26.3                            | 22.0    | 24.2a  |
| **Average**                      | **15.3a**                       | **13.1b**|

Note: The numbers followed by the same lowercase letter in the same column or row show no difference according to the DMRT test at the 5% level, * national varieties (comparison)

The number of tillers of local cultivars from South Banten decreased with longer irrigation frequency, as did the comparison varieties Inpari 10. The seven local cultivars from South Banten had varied numbers of tillers. The number of tillers of local cultivar rice from South Banten can be classified into five classes, namely: having very few tillers (Super cultivar); a small number of tillers (Kapundung cultivar); the number of tillers were medium (cultivars Cimoherang, Rencong, and Kiara) and included the Inpari 10 variety as a comparison; a large number of tillers (Ketan Dewo cultivar); and has the most number of tillers (sticky rice cultivar Elfi). The difference in the number of tillers is understandable because the genes for the number of tillers are an inherited trait and become a source of variation among cultivars planted.

### 3.3. Leaf Proline Content

Based on the results of the analysis of various data on plant leaf proline content, it was shown that the leaf proline content of the plants was different with different irrigation frequencies, as well as the differences among cultivars planted. However, there was no difference in leaf proline content due to the interaction between irrigation frequency and cultivars. The average leaf proline content of local cultivars from South Banten is presented in Table 3.

The leaf proline content of local cultivars from South Banten increased with a longer irrigation frequency, as did the comparison varieties Inpari 10. The seven local cultivars from South Banten varied physiologically as indicated by differences in leaf proline content. Based on the leaf proline content of local cultivar rice plants from South Banten, it can be classified into three classes, namely: high proline content (Super, Cimoherang, Rencong, and Kiara cultivars); moderate proline content (Kapundung and Ketan Elfi cultivars) including Inpari 10 variety as a comparison; and low proline content (Ketan Dewo cultivar). Proline content shows the level of tolerance of plants to limited water availability (drought). The higher the proline content, the more tolerant the plant is to drought.

Proline levels increased with longer frequency of water administration. The longer the water supply frequency, the lower the groundwater content and of course it will decrease the potential value of leaf water and the next will result in increased proline production. The increase in proline plays a role in plant osmoregulation and affects the water potential of plant leaves so that it can increase the potential balance of groundwater and plant water. Physiologically, to be able to maintain the metabolic process in times of lack of groundwater, plants can regulate their osmotic potential to remain negative by producing osmoregulatory compounds such as proline. This is in line with the results of [12] study,
that the result of water deficiency causes osmoticum accumulation in the form of free proline to increase in leaves, which functions to maintain the water potential of plant tissue in the osmoregulation mechanism.

Table 3. Average leaf proline content of local cultivars from Banten with different irrigation frequencies

| Local Cultivar Rice Origin Banten | Frequency of Water Supply (days) | Average |
|----------------------------------|----------------------------------|---------|
|                                  | 7                                | 9       |
|                                  | .....................................(μmol/g)...............................................
| Rencong (k₁)                    | 14,689                           | 27,82   | 21,255bc |
| Ketan Dewo (k₂)                 | 6,120                            | 7,92    | 7,021a   |
| Kiara (k₃)                      | 5,867                            | 30,44   | 18,154bc |
| Inpari 10 (k₄)*                 | 11,800                           | 13,24   | 12,523ab |
| Super (k₅)                      | 17,354                           | 33,60   | 25,477c  |
| Kapundung (k₆)                  | 3,693                            | 19,68   | 11,685ab |
| Cimoherang (k₇)                 | 14,213                           | 33,41   | 23,813c  |
| Ketan Elfi (k₈)                 | 2,606                            | 19,82   | 11,212ab |
| **Average**                     | **9,543a**                       | **23,242b**|

Note: The numbers followed by the same lowercase letter in the same column or row show no difference according to the DMRT test at the 5% level, * national varieties (comparison)

Proline levels increased sharply in local cultivars Ketan Elfi (8 times), Kiara and Kapundung (5 times) followed by Rencong, Super, and Cimoherang cultivars (2 times), while Ketan Dewo increased slightly as well for Inpari 10 varieties as comparison. Thus, based on the physiological characteristics of leaf proline content, cultivars categorized as drought tolerant or adaptive were the Elfi, Kiara, and Kapundung sticky rice cultivars.

3.4. Dry Grain Weight

Table 4. Average dry grain weight per crop of local cultivars from Banten with different irrigation frequencies

| Local Cultivar Rice Origin Banten | Frequency of Water Supply (days) | Average |
|----------------------------------|----------------------------------|---------|
|                                  | 7                                | 9       |
|                                  | .....................................(g)...............................................
| Rencong (k₁)                    | 11,78                            | 4,45    | 8,12cd   |
| Ketan Dewo (k₂)                 | 21,07                            | 15,45   | 18,26ab  |
| Kiara (k₃)                      | 11,21                            | 8,25    | 9,73c    |
| Inpari 10 (k₄)*                 | 26,26                            | 14,92   | 20,59a   |
| Super (k₅)                      | 1,30                             | 0,95    | 1,13e    |
| Kapundung (k₆)                  | 0,85                             | 1,32    | 1,09e    |
| Cimoherang (k₇)                 | 3,92                             | 0,87    | 2,39e    |
| Ketan Elfi (k₈)                 | 23,33                            | 5,33    | 14,33c   |
| **Average**                     | **12,47a**                       | **6,44b**|

Note: The numbers followed by the same lowercase letter in the same column or row show no difference according to the DMRT test at the 5% level, * national varieties (comparison)

Based on the results of the analysis of various data on the dry weight of grain harvested per plant, it shows that the dry weight of harvested unhulled rice per plant is different with different irrigation frequencies as well as differences in cultivars planted. However, the weight of harvested dry grain did
not show any differences due to the interaction between the two factors. The average dry grain weight per crop of local cultivars from South Banten with different irrigation frequencies is presented in Table 4.

The weight of harvested dry grain per local cultivar plant from South Banten can be classified into three classes, namely: high yield dry grain weight per plant (Ketan Dewo) in the same class with Inpari 10 variety as a comparison; medium weight of harvested dry grain per plant (cultivars of Ketan Elfi, Kiara, and Rencong); harvested dry grain weight per plant was low (cultivar Cimoherang, Super, and Kapundung). Thus, based on the dry grain weight of the harvest, it can be seen that the Ketan Dewo cultivar equals the comparison variety, Inpari 10, which is classified as drought tolerant rice.

4. Conclusions
Local rice cultivars from South Banten which are tolerant to drought conditions based on leaf proline content are Ketan Elfi, Kiara, and Kapundung cultivars while based on the yield of harvested dry unhulled rice is the Ketan Dewo cultivar. Further research needs to be done to use the Elfi, Kiara, Kapundung, and Ketan Dewo cultivars as ingredients for selecting plants that have drought tolerant properties.

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References
[1] Lantarsih R et al 2011 National food security system: contribution of energy availability and consumption and optimization of rice distribution Anal. Kebijak. Pertan., 9 33
[2] Hadi P U and Susilowati S H 2010 Prospects, problems and strategies for meeting basic food needs Bio-Energy Clim. Chang 25 35
[3] Tubur H W et al 2012 Agronomy response of rice varieties to drought periods in agronomic rice system responses of low land rice varieties to drought periods J. Agron. Indones 40 167
[4] Okonya J S et al 2013 Farmers’ Perception of and coping strategies to climate change: evidence from six agro-ecological zones of Uganda J. Agric. Sci. 5 252
[5] Thuy P T et al 2014 Integration of adaptation and mitigation in climate change and forest policies in Indonesia and Vietnam Forests 5 2016
[6] Widoretno W and Winarsih L 2005 The effect of drought stress on the vegetative phase on the content of prolin, dissolved total sugar in some soy genes [Glycine max (L.) Merr.] J. Ilmu-ilmu Hayati Life Sci 42 1
[7] Hasanah Y and Rahmawati N 2014 Production and physiology of soybeans in drought-stricken conditions with the application of Genistein-induced Bradyrhizobium japonicum J. Agron. Indones.42
[8] Setiawan et al 2012 The effect of drought on patchouli prolin (Pogostemon cablin Benth) Ilmu Pertan. 15 85
[9] Li D et al 2013 Effects of elevated CO$_2$ on the growth, seed yield, and water use efficiency of soybean ( Glycine max ( L.) Merr.) under drought stress,” Agric. Water Manag 129 105
[10] Justin J R and Fehr W R 1988 Principles of Cultivar Development, vol. 1, Theory and Technique (New York: Macmillan Publishing Corporation)
[11] Poehlman and Sleper 1995 Breeding Field Crops (Iowa: Iowa State University Press)
[12] Bray E A 1997 Plant responses to water deficit,” Trends Plant Sci 2 48
[13] Levitt J 1980 Responses of Plants to Environmental Stress. Vol. II. Water, Radiation, Salt, and other Stresses (New York: Acad Press) p 607
[14] Rusmana 2011 Response ratio of root decay, prolin content and seed weight of various local kultivar peanuts and groundwater content J. Agrivigor 11 80