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# GORONTALO LOCAL RICE EVALUATION FOR DROUGHT TOLERANCE AT THE EARLY GROWTH STAGE

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## SUMMARY

The following research aimed to determine the tolerance of four local Gorontalo rice (*Oryza sativa* L.) genotypes to drought through the PEG-6000 induction method, conducted in 2024 at the Laboratory of Seed Science and Technology, Hasanuddin University, Makassar, Indonesia. This research continued in a completely randomized design with two factors. The first factor comprised the six rice genotypes, including two national genotypes (Ciherang and Situ Bagendit), in comparison with four local Gorontalo genotypes (Ponda, Pulo Kuku, Pulo Merah, and Temo). The second factor was PEG concentrations in three levels, i.e., 0 g $L^{-1}$ (control), 12.5 g $L^{-1}$, and 25 g $L^{-1}$. The PEG-6000 utilization as a selection agent for drought-tolerant rice proved to have a significant effect on the germination process and seedling growth. Four local Gorontalo rice genotypes notably showed no resistance to drought stress, whereas the drought-tolerant indices of the four rice genotypes (Ponda, Pulo Kuku, Pulo Merah, and Temo) scored more than 1.00, being classified as sensitive genotypes. Therefore, the planting of these four local rice genotypes must include abundant water management to optimize their growth and production.

**Keywords:** Gorontalo rice (*O. sativa* L.), local rice, germination, PEG-6000, drought tolerance indices

**Key findings:** Four local Gorontalo rice (*O. sativa* L.) genotypes were distinct in having no resistance to drought stress, and the drought tolerance indices were more than 1.00 for the genotypes Ponda, Pulo Kuku, Pulo Merah, and Temo, classified as sensitive genotypes.

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## INTRODUCTION

Rice (*Oryza sativa* L.) is a cereal crop used as a staple food by more than half of the world's population. The global rice consumption projection remains at 522.0 million tons in 2023–2024, as elevated domestic and international prices likely reduce rice usage for animal feed and limit per capita food consumption growth, except in certain Asian countries, North America, and Europe (FAO, 2022). As the population increases, the rice demand as a staple continues to rise. However, global warming currently affects the production of field crops, including rice. Drought is one of the critical factors caused by global warming. Drought decreases precipitation and enhances evaporation rates in an area, directly affecting crops under this stress condition. The drought being a limiting factor reduces crop production by 50% (Nelson *et al.*, 2014).

Rice is a major staple food in Indonesia. Indonesia's rice production reached 53.98 million tons in 2023. However, globally, the projected rice production is 523,404 metric tons in 2028–2030, while the projected consumption reaches 525,516 metric tons (Durand-Morat and Bairagi, 2021). The said projection illustrates the gap between production and consumption, and increasing rice productivity over time is crucial. In Indonesia, rice production is a contribution of the national genotypes that the farming community commonly uses for cultivation. However, some regions also rely on specific local rice genotypes, and the Gorontalo Province in Indonesia has developed the local rice genotypes. Local rice varieties from Gorontalo may possess unique flavors, textures, or nutritional profiles that appeal to niche markets. Their cultivation supports cultural heritage and traditional farming practices, adding socio-economic value to the region.

The local community still cultivates the local rice genotypes, mostly grown on moorland (with no irrigation system) in Gorontalo Province, Indonesia. The option of rice cultivation on moorland (with no irrigation system) has the potential to fulfill the rice demand on the national scale because it does not depend on the irrigation system requiring much water. Therefore, the development and use of local rice genotypes can be a better solution for adaptation to drought stress conditions. Rice genotype assembly is an ongoing effort to maintain crop productivity (Pandey and Shukla, 2015).

Determining rice genotype tolerance at an early growth stage (germination) can proceed with the help of a PEG (polyethylene glycol) solution that can induce drought around the seed (Elmaghrabi *et al*., 2017; Rajeswar and Narasimhan, 2021). Moreover, the ability of PEG to control the decrease in water potential is homogeneous to mimic the soil water potential. The tolerance trait to drought stress is principally relative to plant efforts in maintaining osmotic drought by increasing water absorption and reducing water loss through transpiration and evaporation (Yang *et al*., 2022).

The rice genotypes' selection can be successful by using the appropriate selection material to enhance the chances of getting the desired breeding material characters. Based on a previous research, it reported that PEG 6000 proved as a suitable selection material to obtain the drought-tolerant genotypes in taro (Susetio *et al.*, 2019) and soybean (Joulanda, 2023). The PEG used for controlled water potential experiments has proven to be a very effective method for studying the impact of water shortage in the early vegetative phases (Harahap *et al.*, 2013; Hapsari *et al*., 2018).

From the above description, the objective of this research was to evaluate the drought resistance of several local rice genotypes from Gorontalo Province, Indonesia at the germination stage under polyethylene glycol (PEG)-induced drought stress. The presented findings will undoubtedly be helpful information in empowering and assembling the drought-resistant local rice genotypes.

## MATERIALS AND METHODS

### Experimental procedure

The potential research commenced from February to April 2024 at the Laboratory of

Plant Breeding and Seed Science, Hasanuddin University, Makassar, Indonesia. The said experiment layout was in a completely randomized design (CRD) with factorial arrangement and three replications. The first factor comprised six rice (*O. sativa* L.) genotypes, including two national genotypes (Ciherang and Situ Bagendit) in comparison with four local Gorontalo genotypes (Ponda, Pulo Kuku, Pulo Merah, and Temo). Ciherang and Situ Bagendit served as comparison varieties, currently being used nationally by farmers and are drought tolerant. The second factor was PEG concentrations with three different levels, i.e., 0 g $L^{-1}$ (control), 12.5 g $L^{-1}$, and 25 g $L^{-1}$. Each treatment continued three times to obtain a total of 54 experimental units.

Obtaining the seeds of local Gorontalo rice genotypes came from the farming community of Sigaso Village, District Atingola, North Gorontalo Regency, Indonesia. The seed collection came from planting in the same season. All the genotypes' seeds when selected had uniform size and no physical damage. The seeds then received soaking in distilled water for 15 minutes. Next, the seeds upon drying with tissue, got placed in a Petri dish covered with filter paper before applying the PEG solution (15 mL per sheet), according to the treatment's concentration, with the control treatment given only the distilled water.

### Data recorded and statistical analysis

Fifty-four dishes contained 100 rice seeds, with a uniform spacing arrangement. The seeds' germination proceeded at room temperature for 14 days. The recording of rice seeds as germinated as and when radicles appeared with a length of ±2 mm. Moreover, the data recording on parameters included final germination percentage, mean germination time, germination speed index, synchrony, plumule and radicle length, fresh and dry weight, vigor index I, vigor index II, and drought tolerance index. The formulas used to determine the values for various parameters are available in Table 1. The recorded data underwent further assessment by using the analysis of variance (ANOVA, $\alpha$ = 0.05). Furthermore, an LSD test was successful at the level of $\alpha$ = 0.05. The data as analyzed used the R-Studio software and the SeedCalc package (Silva *et al.*, 2019).

## RESULTS AND DISCUSSION

The rice (*O. sativa* L.) genotypes and PEG concentrations, as well as their interactions, significantly affected several germination performance parameters (Table 2). The highest germination percentage was notable in the national genotype Ciherang with PEG control treatment, while the lowest resulted in the local genotype Pulo Merah with a PEG concentration of 25%. The six rice genotypes tested consistently experienced a decrease in germination with increased PEG concentrations. National rice genotypes Ciherang and Situ Bagendit revealed nonsignificant differences at three different PEG concentrations. However, the four local rice genotypes Ponda, Pulo Kuku, Pulo Merah, and Temo suffered an extreme decrease in germination at the PEG of 25%, with consecutive values of 50.86%, 44.60%, 82.14%, and 41.57%. Similar observations were also apparent in the average germination time parameter, where the genotypes Ciherang and Situ Bagendit showed nonsignificant differences for average germination times at three different PEG concentrations. However, the other four genotypes demonstrated a much longer delay in germination time than for 0% PEG. The shortest mean germination time appeared for the genotype Situ Bagendit with the PEG control treatment, while the longest time arose for the genotype Ponda with a PEG concentration of 25%.

The presented research showed the PEGs revealed a significant effect on rice seeds' germination process. PEG is a commonly used tool to assess drought stress tolerance in the germination process. PEG can reduce the water potential around the seed, which will inhibit the imbibition process (Sobahan *et al*., 2022). Dry stress significantly affects growth and both vegetative and generative phases (Khaton *et al*., 2016). The effects of water stress include variations in membrane transport, disruption of metabolic processes, and decreased ATP synthesis, leading to a halt in germination and, eventually, reduced seedling growth (Oladosu *et al*., 2019; Kota *et al*., 2023). Transcriptional and hormonal activities and ROS levels also emerged severely affected when imbibition and seedling development occur under water stress conditions (Ishibashi *et al*., 2018; Kawaguchi *et al*., 2023). It is evident that in some parameters of germination and seedling performance, growth was also inhibited due to increased PEG concentration, although it was not comprehensive in the observed variables of rice.

The final germination percentage consistently decreased across the rice genotypes evaluated with increased PEG concentrations. Likewise, the average germination time considerably extended more than the seeds without PEG treatments. The much excellent average value of germination time was linear with the smaller value of germination speed index. The germination process inhibition occurred due to the PEG treatments. PEG can increase the osmotic pressure that inhibits water from entering the seed for the metabolic process of the seed not to take place optimally, which activate the process of inhibiting germination, causing the length of the radicle to grow and penetrate the seed coat. Additionally, drought stress induced through PEG can cause cell damage due to the production of highly reactive oxygen species (Khan *et al*., 2019). However, the national rice genotypes (Ciherang and Situ Bagendit) showed the highest germination at the PEG concentration of 25%, revealing a 95% germination. This was quite a good performance, considering that seed germination with more than 70%, occurred under low levels of drought stress conditions (Evamoni *et al*., 2023).

**Table 1.** The observed parameters with their formulas.

| No. | Parameters | Formulas |
|---|---|---|
| 1 | Final Germination Percentage (FGP) | FGP = (n/N) × 100<br>n is the number of seeds germinated, and N is the total number of seeds. |
| 2 | Germination Speed Index (GSI) | GSI = $\sum_{i=1}^{n}(\frac{ni}{ti})$<br>n is the number of seeds germinated on each day of daily counting up to the last count, and t is the number of days after the beginning of the test in each count. |
| 3 | Mean Germination Time (MGT) | MGT = $\sum_{i=1}^{k}(\mathrm{niti}) / \sum_{i=1}^{k}\mathrm{ni}$<br>ni is the number of seeds germinated per day (not the accumulated number, but the number corresponding to the i-th observation), and $t_i$ is the time since the beginning of the germination test up to the i-th observation. |
| 4 | Germination Synchrony (Sync) | Sync = $\sum Cni$, 2 / N<br>Cni, 2 = ni(ni − 1) / 2<br>N = $\sum ni\,(\sum ni - 1)$ / 2<br>Cni is the combination of the seeds germinated in time i, two by two, and ni is the number of seeds germinated in time i. |
| 5 | Plumule Length | Plumule length measurement occurred at the end of the observation on day 14 using a ruler. |
| 6 | Radicle Length | Radicle length measurement transpired at the end of the observation on day 14 using a crossbar. |
| 7 | Vigor Index I | IVI: FGP × Seedling Length |
| 8 | Vigor Index II | IVII: FGP × Seedling Weight |

Source: Silva *et al*., 2019

**Table 2**. Rice genotypes with germination (%), average germination time, germination speed index, and synchrony.

| Genotypes | PEG (%) | FGP (%) | MGT (d) | GSI | Sync |
|---|---|---|---|---|---|
| | 0 | 99.00 | 3.09 | 32.48 | 0.90 |
| Ciherang | 12.5 | 98.00 | 3.10 | 32.00 | 0.87 |
| | 25 | 97.00 | 3.30 | 30.69 | 0.78 |
| | 0 | 98.33 | 3.06 | 32.28 | 0.94 |
| Situ Bagendit | 12.5 | 98.00 | 3.12 | 31.87 | 0.84 |
| | 25 | 97.00 | 3.27 | 30.92 | 0.84 |
| | 0 | 96.33 | 3.97 | 25.78 | 0.63 |
| Ponda | 12.5 | 95.67 | 4.76 | 22.06 | 0.38 |
| | 25 | 47.33 | 9.48 | 5.27 | 0.23 |
| | 0 | 89.67 | 3.97 | 24.60 | 0.37 |
| Pulo Kuku | 12.5 | 83.67 | 5.33 | 17.19 | 0.31 |
| | 25 | 49.67 | 9.23 | 6.47f | 0.20 |
| | 0 | 84.00 | 4.95 | 18.71 | 0.29 |
| Pulo Merah | 12.5 | 69.00 | 6.54 | 12.16 | 0.33 |
| | 25 | 15.00 | 9.23 | 1.62 | 0.70 |
| | 0 | 97.00 | 3.96 | 27.21 | 0.65 |
| Temo | 12.5 | 92.67 | 4.64 | 21.66 | 0.33 |
| | 25 | 56.67 | 9.13 | 6.88 | 0.55 |

Description: The average, followed by lowercase letters in the same column are not significantly different in the LSD alpha 0.05 test. FGP=final germination percentage, MGT=mean germination time, GSI=germination speed index, and Sync=synchrony.

The parameters of germination speed index and synchrony also sustained influences from the rice genotypes, PEG concentrations, and their interactions (Table 2). The highest germination speed index resulted in the genotype Ciherang with the PEG control treatment. In contrast, the lowest germination speed index appeared in the local genotype Pulo Merah with a PEG concentration of 25%. An increase in PEG concentration consistently decreased the value of germination speed in all the rice genotypes. However, the national rice genotypes Ciherang and Situ Bagendit have the same germination speed index with the three PEG concentrations. Furthermore, the rice genotypes showed similar results for synchrony, and an increase in PEG concentration consistently lessened the synchrony values, except for the local genotype Pulo Merah, which experienced an increase in the synchrony value with a rise in PEG concentration. However, the minimum synchrony value manifested in the local genotype Pulo Kuku with a PEG concentration of 25%. In contrast, the maximum value for synchrony was evident in the national genotype Situ Bagendit with the PEG control treatment.

For germination uniformity, the rice genotypes displayed heterogeneous findings. The four rice genotypes, such as the two national (Ciherang and Situ Bagendit) and the two local (Ponda and Pulo Kuku) genotypes, exhibited the highest germination uniformity with an increased PEG concentration. Contrastingly, the local genotype Pulo Merah experienced non-uniformity at the PEG concentration of 25%, while the genotype Temo emerged with the topmost uniformity at the PEG concentration of 12.5%. Synchrony values close to zero (0) indicate the highest uniformity in seedling growth; otherwise, if the synchrony value was close to unity, it means a low uniformity in seedling growth (Sales *et al*., 2013).

For seedling length, the rice genotype, PEG concentrations, and their interactions significantly affected the plumule and radicle length (Table 3). The interaction of rice genotype Pulo Kuku and PEG (12.5%) recorded the maximum plumule length, while the least plumule length was visible in the genotype Pulo

**Table 3**. Rice genotypes with plumule length, radicle length, vigor index I, and vigor index II.

| Genotypes | PEG (%) | PL (cm) | RL (cm) | VI I | VI II |
|---|---|---|---|---|---|
| | 0 | 7.38 | 6.07 | 1332.68 | 99.63 |
| Ciherang | 12.5 | 7.32 | 6.77 | 1381.14 | 103.46 |
| | 25 | 7.70 | 8.49 | 1569.35 | 101.23 |
| | 0 | 8.64 | 8.10 | 1646.63 | 106.13 |
| Situ Bagendit | 12.5 | 8.74 | 7.92 | 1634.05 | 106.70 |
| | 25 | 8.50 | 8.61 | 1659.67 | 99.76 |
| | 0 | 7.87 | 8.55 | 1582.96 | 79.62 |
| Ponda | 12.5 | 7.86 | 7.20 | 1440.97 | 60.81 |
| | 25 | 3.13 | 4.12 | 349.71 | 21.84 |
| | 0 | 9.36 | 11.17 | 1841.14 | 102.40 |
| Pulo Kuku | 12.5 | 9.49 | 10.27 | 1654.25 | 66.80 |
| | 25 | 3.47 | 4.09 | 402.21 | 26.59 |
| | 0 | 8.73 | 9.03 | 1492.60 | 75.79 |
| Pulo Merah | 12.5 | 9.66 | 10.09 | 1362.11 | 46.37 |
| | 25 | 2.17 | 4.09 | 99.01 | 5.75 |
| | 0 | 9.40 | 9.09 | 1794.42 | 86.98 |
| Temo | 12.5 | 9.13 | 7.91 | 1576.49 | 75.26 |
| | 25 | 4.99 | 3.70 | 532.63 | 29.50 |

Description: The average, followed by lowercase letters in the same column are not significantly different in the LSD alpha 0.05 test. PL=plumule length, RL=radicle length, VI I=vigor index I, and VI II=vigor index II.

Merah with a PEG concentration of 25%. Two local rice genotypes (Ponda and Temo) experienced a decrease in plumule length with increased PEG concentrations. In comparison, the other four genotypes underwent an enhancement in plumule length with PEG concentrations of 12.5% and 25.0%. Furthermore, for the trait of radicle length, two genotypes (Pulo Kuku and Temo) signified a decrease in radicle length with an increased PEG concentration. The other four rice genotypes experienced augmented radicle length with PEG concentrations (12.5% and 25%). The interaction of the rice genotype Pulo Kuku with the PEG control provided the maximum radicle length, while the minimum radicle length was prominent in the genotype Temo with 25% PEG concentration.

Rice local genotypes Ponda and Temo revealed a decline in plumule growth along with an increase in PEG concentration. The local three rice genotypes, Ponda, Pulo Kuku, and Temo, experienced inhibition in radicle growth as the PEG concentration increased. The growth inhibition has a direct influence from insufficient water experienced by the seeds carrying out their metabolic processes. Reports of the PEG effect on the germination process also emerged on various characteristics of different crop plants (Kososidis *et al*., 2020). Similarly, Muscolo *et al*. (2013) stated the induction of drought stress in plants reduced the germination process, and the activity of amylase and glucosidase enzymes decreased. Drought stress directly inhibits the radicle growth due to limited water that plants can absorb, which causes shorter seedling growth than in optimal conditions. Moreover, the drought stress can reduce seedling growth characterized by a reduction in plumule and radicle length (Siddique *et al*., 2023).

Some rice genotypes experienced an increase in plumule growth with a PEG concentration of 12.5%, such as Pulo Kuku, Pulo Merah, and Situ Bagendit. Relatedly, the radicle growth increased in the genotypes Ciherang and Pulo Merah. This phenomenon can be an indication of the positive effect of PEG on germination. It was noteworthy that the PEG concentration (15%) significantly affected drought induction, and even the PEG concentration of 25% was the highest concentration as most optimally used in simulating the drought stress. Previous findings indicated PEG as an ideal agent for germination screening due to its high molecular weight preventing water entry through the plant cell wall (Sagar *et al*., 2020; Sobahan *et al*., 2022).

The vigor indexes I and II acquired significant influences from the genotypes, PEG concentrations, and their interactions (Table 6). The highest vigor index I was notable for the local rice genotype Pulo Kuku with the PEG control (1841.1), while the lowest value (99.01) was prominent for the genotype Pulo Merah with PEG (25%). A linear decrease in vigor index I and II values with increasing PEG concentration resulted in four genotypes, i.e., Ponda, Pulo Kuku, Pulo Merah, and Temo. The two national rice genotypes (Ciherang and Situ Bagendit) showed at-par values of vigor index I and II with three PEG concentrations.

The maximum vigor index II value appeared in the rice genotype Situ Bagendit with the PEG control treatment, while the minimum emerged in the local genotype Pulo Merah with a PEG concentration of 25%. The effect on rice seed germination and seedling performance directly impacts the seedling vigor index I and II. A linear decrease in the vigor index values I and II was noticeable with an increased PEG concentration in the four local rice genotypes (Ponda, Pulo Kuku, Pulo Merah, and Temo). Past research showed increasing PEG concentrations significantly reduced the vigor index of plant seedlings, based on decreased performance and inhibited seedling growth (Hellal *et al*., 2017).

The fresh and dry weight of seedlings had no direct effects from the interaction between rice genotypes and PEG concentrations; however, individually the genotypes and PEG concentrations significantly affected these traits (Table 4). The highest average fresh weight of seedlings occurred in the national genotype Situ Bagendit, while the lowest arose in the local genotype Ponda. The heaviest seedling dry weight was remarkable in the genotypes Situ Bagendit and Temo, while the lightest seedling dry weight manifested in the genotypes Ponda and Pulo Merah. The six rice genotypes revealed significant differences in seedling fresh and dry weights. The fresh weight of the seedlings gradually decreased as the PEG concentration increased. Fatimah *et al*. (2023) reported a decline in seedling weight, which provided an inhibition of rice growth characterized by slow growth of shoots, roots, and seedling weight in the PEG treatments.

In the rice genotypes, the lower fresh weight at the PEG concentration of 25% gained a direct influence from the size of the seedlings due to a shorter radicle and plumule. Chun *et al*. (2021) reported a decrease in root length with increased drought stress conditions. The reduced root elongation due to drought stress can refer to the destruction of root meristem cells and the disruption of cell division and elongation processes. However, it was contrary in dry weight, and the increased PEG concentration demonstrated an increased dry weight of seedlings. Similarly, Ghosh *et al*. (2020) reported the drought stress with PEG induction increased the dry weight in plant seedlings.

**Table 4.** Rice genotypes with fresh and dry weight of the seedlings.

| Genotypes | FW (g) | DW (g) |
|---|---|---|
| Ciherang | 1.03 | 0.21 |
| Ponda | 0.63 | 0.17 |
| Pulo Kuku | 0.81 | 0.19 |
| Pulo Merah | 0.64 | 0.17 |
| Situ Bagendit | 1.06 | 0.22 |
| Temo | 0.72 | 0.22 |
| PEG (%) | FW (g) | DW (g) |
| 0 | 0.97 | 0.18 |
| 12.5 | 0.84 | 0.19 |
| 25 | 0.64 | 0.22 |

Description: The average, followed by lowercase letters in the same column are not significantly different in the BNT alpha 0.05 test. FW=fresh weight and DW=dry weight.

**Table 5.** Rice genotypes with drought tolerance index.

| Genotypes | FG | PL | RL | FW | DW | IV I | IV II |
|---|---|---|---|---|---|---|---|
| Ciherang | -0.04 | -0.90 | -0.32 | 1.77 | -0.09 | -0.05 | 0.04 |
| Situ Bagendit | 0.02 | -0.13 | 0.08 | 0.34 | 0.00 | 0.03 | 0.02 |
| Ponda | 1.72 | 2.27 | 1.89 | 1.42 | 0.71 | 1.04 | 0.66 |
| Pulo Kuku | 1.79 | 1.31 | 1.55 | 2.20 | 0.71 | 1.00 | 0.98 |
| Pulo Merah | 2.05 | 0.95 | 2.55 | 0.86 | 0.95 | 2.08 | 2.06 |
| Temo | 1.45 | 2.30 | 1.46 | -0.42 | 0.64 | 0.77 | 0.49 |

Description: If the value is $P \leq 0.5$ (tolerant), 0.5 < value ≤ 1.0 (moderate), and >1.0 (sensitive).

**Table 6.** Correlation among various rice parameters.

| Traits | FGP | MGT | GSI | Sync | PL | RL | FW | DW | VI I | VI II |
|---|---|---|---|---|---|---|---|---|---|---|
| FGP | 1 | -0.850** | 0.887** | 0.266$^{NS}$ | 0.765** | 0.590** | 0.712** | 0.009$^{NS}$ | 0.895** | 0.852** |
| MGT | | 1 | -0.952** | -0.500* | -0.746** | -0.619** | -0.763** | 0.001$^{NS}$ | -0.883** | -0.864** |
| GSI | | | 1 | 0.573* | 0.659** | 0.510* | 0.783** | 0.127$^{NS}$ | 0.818** | 0.897** |
| Sync | | | | 1 | 0.133$^{NS}$ | -0.023$^{NS}$ | 0.435* | 0.213$^{NS}$ | 0.208$^{NS}$ | 0.472* |
| PL | | | | | 1 | 0.800** | 0.613** | -0.231$^{NS}$ | 0.921** | 0.668** |
| RL | | | | | | 1 | 0.579* | -0.234$^{NS}$ | 0.858** | 0.585* |
| FW | | | | | | | 1 | 0.157$^{NS}$ | 0.732** | 0.965** |
| DW | | | | | | | | 1 | -0.120$^{NS}$ | 0.146$^{NS}$ |
| VI I | | | | | | | | | 1 | 0.819** |
| VI II | | | | | | | | | | 1 |

Description: *: Significant at the 5% level, r = 0.468, **: Significant at the 1% level, r = 0.590, NS: Non-significant at the 0.05 and 0.01 levels. FGP=final germination percentage, MGT=mean germination time, GSI=germination speed index, Sync=synchrony, PL=plumule length, RL=radicle length, FW=fresh weight, DW=dry weight, VI I=vigor index I, and VI II=vigor index II.

The use of six rice variables as the primary basis helped determine the drought tolerance index value (Table 5). The six rice genotypes tested had varying index values of less than 0 and more than 1. A drought tolerance index of less than 0.50 becomes highly drought tolerant, those between 0.51 and 0.75 are drought tolerant, and those above 1.00 are drought susceptible (Aditya *et al*., 2022). The rice genotype Situ Bagendit attained classification as the most tolerant genotype in all variables. Ciherang has a tolerant index category in six variables, i.e., germination percentage, plumule and radicle length, and vigor indexes I and II. However, the local rice genotypes, Ponda, Pulo Kuku, and Pulo Merah, did not classify as tolerant in all those variables. Simultaneously, the local genotype Temo received a tolerant classification in the fresh weight and vigor index II variables. The local rice genotypes Ponda, Pulo Kuku, and Pulo Merah sustained a sensitive category, while Temo was moderate and Ciherang and Situ Bagendit were tolerant genotypes. The results revealed the four local Gorontalo rice genotypes do not have tolerance to drought. Ciherang, being a national genotype, has been proven resistant to drought stress conditions (Akbar *et al*., 2018). On the other hand, the Situ Bagendit variety has a low drought resistance index (Ruminta *et al.*, 2016).

Based on the correlation analysis conducted on various parameters, very diverse values surfaced (Table 6). The correlation vigor index I values with other parameters with a significant effect were 0.895 (germination percentage), -0.863 (average germination time), 0.818 (germination speed index), 0.921 (plumule length), 0.858 (radicle length), and 0.732 (fresh weight). The correlation of vigor index II scores with other parameters having a significant effect were 0.852 (germination percentage), -0.864 (average germination time), 0.897 (germination speed index), 0.472 (synchrony), 0.668 (plumule length), 0.585 (radicle length), 0.966 (fresh weight), and 0.819 (vigor index I). The correlation analysis indicated that various germination parameters had a considerable relationship with the seedling vigor index values, based on the weight and length of the seedling.

The germination percentage, germination rate index, plumule length, radicle length, and fresh weight proved positively correlated with the vigor index I, with classifications as highly significant correlations. The categorization of the relationship had a basis in the research of Mukaka (2012), which divided the correlation relationship into five categories, i.e., 0.9–1.0 (very strong), 0.7–0.9 (strong), 0.5–0.7 (moderate), 0.3–0.5 (weak), and 0.0–0.3 (very weak). Furthermore, the average germination time parameter consistently correlated negatively with vigor indexes I and II.

## CONCLUSIONS

The use of PEG-6000 as a selection agent for drought-tolerant rice (*O. sativa* L.) significantly affected the germination process and seedling growth. Four local Gorontalo rice genotypes, as recorded, were not resistant to drought stress. The drought tolerance index values of the local rice genotypes Ponda, Pulo Kuku, Pulo Merah, and Temo were more than 1.00, classifying them as sensitive genotypes. Therefore, the cultivation of these four local rice genotypes requires better water management to optimize their growth and production.

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