Drought test resistance of maize varieties through PEG 6000

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Abstract. The germination phase is a very critical time for corn plants against water stress. Corn resistance to water stress in this phase is very different between cultivars. This initial test has been carried out in the Laboratory to determine the resistance level of some varieties of corn to water stress during the germination phase by using Poly Ethylene Glycol (PEG) 6000. There are nine corn varieties tested at three levels of PEG 6000 concentration of 0% (0.00 MPa), 10% (-0.19 MPa), and 20% (-0.67 MPa). The experiment used a completely randomized 9 x 3 factorial design with 2 replications. The nine varieties tested were: Anoman 1 (V1), Lamuru (V2), Gumarang (V3), Srikandi Kuning (V4), Sukmaraga (V5), Bisma (V6), Arjuna (V7), Lagaligo varieties (V8), and NK-Jumbo varieties (V9). Selection of maize varieties on water stress during the germination phase of 9 selected varieties into 3 varieties consisting of one tolerant variety, one moderately tolerant variety and one sensitive variety through prediction of a PEG 6000 osmoticum solution in the germination phase. The experimental results showed that the concentration of PEG 6000 affected the response of nine corn varieties to germination and seed vigor. The most tolerant (resistant) corn varieties are NK-Jumbo (V9) and the moderately resistant varieties (medium) are Srikandi Kuning (V4) while the intolerant (sensitive) varieties are Lamuru (V2).

1. Introduction
Maize is estimated to be more resistant to drought because it has a deeper root than rice, so even though the dry season lasts, but this plant is still possible to produce results even though in small amounts. So far, the increased need for corn has been caused by an increase in Indonesia's corn consumption which has reached 28.4 kg per capita per year [1]. These needs include the demand for corn for the development of the animal feed industry which according to BPS estimates in 2011 reached 6.8 million tons.

Drought is an abiotic environmental factor that is very influential on plants which results in growth retardation and decreases in crop yields almost equaling losses caused by a combination of other natural disasters [2]. This phenomenon is a serious obstacle to crop production and food security. Drought can also reduce water and plant turgor potential [3]. Water is a basic requirement in all phases of plant growth and development, without water the plant will suffer from drought, the presence of water is very important at the stage of plant germination [4], and it is also a limiting factor in arid and semi-arid areas in many part of the world. Drought stress is a major environmental factor affecting
leaf growth, roots, stomata content, photosynthesis and accumulation dry matter [5]. One of the most important connecting structures of plants to the environment is stomata with guard cells found in leaf epidermis. Anf play a role in tolerance to environmental change [6].

Furthermore [7] added that drought stress is very influential on the characteristics of plant photosynthesis, this event results in photosynthesis and leaf chlorophyll content being reduced [8]. The manifestation of plant responses to drought is a complex physics-chemical process and affects the formation of many large and small biological molecules such as nucleic acids, proteins, fats, hormones, free radical ions and minerals [9]. Water stress affects every phase of plant development, however stress damage is more pronounced when it occurs in important growth phases such as germination, shoot and root growth, flowering and seed formation [10].

The resistance of corn varieties to drought stress can be predicted using poly ethylene glycol (PEG). PEG is a compound that has a high molecular weight and is important for controlling and inhibiting seed germination by creating osmotic stress in plants. The response to drought stress varies according to the variety and age of the plant. The results of the research of [11] on 4 varieties at 5 levels of drought treatment with distilled water respectively: 0, -2, -4, -6 and -8 bar, it turns out that corn cultivars showed different vigor of sprouts due to stress treatment drought, where better vigor sprouts are shown by Goldenwest cultivars.

Furthermore [12] used 5 levels of PEG namely 0, -0.2 MPa, -0.4 MPa, -0.6 MPa and -0.8 MPa for screening 8 hybrid corn cultivars against drought stress, the results of a 6525 and 32B33 cultivar study emphasized - show a high tolerance to drought, whereas cultivars Hycorn and 31P41 are very sensitive cultivars compared to other cultivars. Then a selected vigor seed germination vigor through a growth speed test using PEG 6000 at four osmotic potential levels (0; -0.4; -0.8 and -1.2 MPa) under drought and salt stress conditions. It turns out that the provision of PEG 6000 can inhibit the speed of growth of corn plants [13]. Others using five levels of PEG 6000 (0, 0.5; 1.0; 1.5 and 2%) it was found that the increase in concentration was positively correlated with coleoptil length, root length, shoot dry weight, root dry weight and number of roots for selection sorghum in vitro [14]. While the research results of [15] on maize grown on dry land, it turns out that corn yield is always positively correlated with rainfall.

The response of corn to drought is strongly influenced by variety. Every plant that is planted in extreme environmental conditions tries to defend itself in various ways. Corn plants that are planted in the dry season defend themselves by forming narrower or curved leaves and more and deeper roots because each plant is trying to defend itself in conditions extreme environment [16]. The resistance of corn varieties to drought stress can be predicted with using Poly Ethylene Glycol (PEG 6000). PEG is a compound that has a high molecular weight and is important for controlling and inhibiting seed germination by creating osmotic stress in plants. But until now there has not been obtained detailed information about the concentration of PEG that can be used to select maize varieties that are resistant to drought during the germination phase.

2. Materials and methods
The materials used in this study were 10 corn varieties, namely: Anoman 1 (V1), Lamuru (V2), Gumarang (V3), Yellow Srikanth (V4), Sukmaraga (V5), Bisma (V6), Arjuna (V7), Lagaligo Variety (V8), and NK Jumbo Variety (V9), PEG 6000 and plastic cover. Transparent plastic jars. While the tools used include: Microfilter, Plastic box, Measuring cup, Drying oven, Germinator analytical balance And tweezers. This research was carried out in the seed technology laboratory of the Faculty of Agriculture, Syiah Kuala University in June 2016 using a factorial design with a completely randomized basic design pattern (CRD), varieties as the first factor consisted of 9 varieties with successive symbols V1 to V9 as listed on ingredients.

While the second factor is the use of PEG 6000 as done by Effendi and Azral (2010) with a solution of PEG 0% and 10% (-0, -0.19 MPa), but the authors add one more level above it i.e 20% (-0.67 MPa) because [4] have even used PEG to test the growth rate of corn seed up to -1.2 MPa, so there are three levels which are equivalent to 0 MPa, -0.19 MPa and -0.67 MPa symbolized by P, consisting...
of P0, P1 and P2. The treatment combination became 27 types and was repeated 2 times so that it became 54 experimental units. Identification of dry tolerant corn varieties to 10 corn varieties using poly ethylene glycol (PEG) 6000 in the germination phase are: 0% (0 MPa), 10% (-0.19 MPa) and 20% (-0.67 MPa) which each is caused by P0, P1 and P2 because according to Verslues et al., (2006) PEG is the best material to control water potential which can cause plant water potential to decrease, so it is effectively used for the drought stres selection method.

The seeds of each variety are germinated by the roll paper test method in plastic. Each variety is taken at random 20 seeds placed and arranged on 2 sheets of straw paper measuring 30 x 20 cm that has been moistened with PEG 6000 solution and given a plastic base and also covered with 2 sheets of straw paper that has been moistened according to treatment. Paper straw that contains seeds corn from each rolled variety is placed in a plastic box then incubated in a germinator. The dry tolerant adaptation test on 9 varieties of maize was carried out with the following testing stages. Selection of maize varieties against water stress in the germination phase of 9 selected varieties into 4 varieties consisting of 2 sensitive and 2 tolerant varieties through prediction of a PEG 6000 osmoticum solution in the germination phase. Observed parameters This research lasted for 8 days with the observed parameters include:

1. The germination rate (GR) = \( \frac{N_{G\text{ observation I}} + N_{G\text{ observation II}} \times 100\%}{\text{Total seeds tested}} \)
2. Growth speed \( \text{GS} \text{ (% / etmal)} = \frac{N_1 + N_2 + \ldots \ldots \ldots \ldots N_n}{D_1 D_2 D_n} \)
3. Vigor index (VI) = \( \frac{K \text{N with strong vigor} \times 100\%}{\text{Total seeds tested}} \)
4. Growth equalization (GE) = \( nd_2 + nd_4 + \ldots + \text{nd} \times 6 + \text{nd} \times 8 \)
5. Sprouts stress index (SSI) = \( \frac{\text{GE Sprouts that are gripped right} \times 100\%}{\text{GE control}} \)
6. T 50 (days) = \( ti + ((tn_{50\%} - ni)) / (nj - ni) \)
7. Root Weight (RW)
8. Shoot weight (SW)
9. Root-shoot ratio, determined after drying for 2 days.

Root Weight, root weight was weighed at the end of the study, that is on the 8th day. Heading Weights, the weight of the crown is also increased when the study ends, which is on the 8th day. Root dry weights, weighed using analytical scales after drying at 50°C for 3 days. Canopy dry weight, also weighed using analytical scales after drying at a temperature of 80°C for 3 days. Root-shoot ratio, determined after drying for 3 days. All observations were made on the 8th day, except the germination was observed twice, namely on the 5th day and the 8th day.

3. Results and discussion

3.1. Effects of PEG 6000 on seed viability and corn growth

F test results show that the use of PEG is very influential on all the corn germination variables observed except for growth inception (PI), this situation can be presented in Table 1.
Table 1. Average germination, viability, and growth characteristics of corn sprouts after 8 days of incubation due to PEG 6000 concentration

| PEG 6000 concentration | GR (%) | GS (% etmal) | VI (%) | GE (%) | RW (g) | SW (g) | RW/SW | T50 (%) |
|------------------------|--------|--------------|--------|--------|--------|--------|--------|---------|
| 0% (0.00 MPa)          | 98.61 c| 35.36 c      | 89.72 c| 1.59 a | 0.15 c | 0.78 c | 0.35 b | 2.41 a  |
| 10% (-0.19 MPa)        | 91.67 b| 19.41 b      | 63.06 b| 2.22ab | 0.10 b | 0.39 b | 0.42 c | 2.61 a  |
| 20% (-0.67 MPa)        | 3.06 a | 0.18 a       | 3.61 a | 3.48 b | 0.06 a | 0.02 a | 0.26 a | 3.90 b  |

The number followed by the same letter in each row is not significantly different according to the LSD 0.05 test.

Table 1 it can be seen that all viability, vigor and growth characteristics of corn sprouts that were not given PEG were normal, in the concentration of PEG 10% viability, vigor and growth characteristics of corn sprouts were observed to be depressed with decreasing values and at PEG 20% concentration % of all observed corn germination variables showed the lowest value, except the root-canopy ratio where at the time of PEG 10% the canopy ratio was seen to be greater than the corn sprouts that were not given PEG and 20% PEG administration, otherwise the stress index was greater, the half-life for germination is longer and the proline content increases with increasing PEG.

The treatment without PEG (0% PEG) shows the average viability, vigor and growth of corn sprouts are better than the concentration of PEG 10% and 20% PEG. At the concentration of giving 10% PEG can still produce normal sprouts, but at that concentration the viability and vigor of corn has begun to decline and the growth of sprouts began to be depressed. Whereas at the concentration of 20% PEG administration showed very low viability, corn seed vigor was very weak and even most of the observed corn sprout growth was stopped, this meant that corn resistance to drought could be predicted with PEG. PEG selection was effective to assess the level of drought resistance of the 9 corn varieties tested, the best viability and vigor were shown by the NK Jumbo variety (V9) and the weakest viability and vigor were shown by the Lamuru variety. Stronger viability and vigor were also seen in yellow Srikandi (V4) varieties. PEG is a compound that has a high molecular weight and is important for controlling and inhibiting seed germination by creating osmotic stress in plants. The response to stress in plants is a form of drought stress, the results of this study show that drought stress differs according to varieties to maize germination.

The results of this study are in line with research [4] in fact the increase in concentration is positively correlated with the development of Viability, Vigor and other components of corn sprout growth. Drought is an abiotic stress which has a big influence on plantations in many parts of the world which results in decreased growth and crop yields. Water stress affects every stage of plant development. However stress damage is more evident when it occurs together with a number of stages of growth such as germination, seed formation, growth of shoots and roots and flowering [15]. Environmental factor that influences the growth of leaves, roots, stomata content, photosynthesis and accumulation of dry matter. Drought stress is very influential on the characteristics of plant photosynthesis [12]. This event results in photosynthesis and reduced leaf chlorophyll content [6] Many studies have shown that drought stress generally influences plant physiology seen in growth and production.

3.2. Identification of Response of Corn variety on Drought.

F test turned out to be that the varieties affect the germination (DB), Vigor Index (IV), growth speed (GS), Dry Root Weight (DRW), Dry Shoot Weight (DSW), Root-Shoot ratio (RW/SW), Tn 50% and proline content but the variety has no effect on root weight (RW), shoot weight (SW), growth equilibrium (GE), and different sprouts stress index (SSI). The average viability, vigor index, sprout growth and proline content due to different varieties are presented in Table 2.
Table 2. Average parameters for sprouting and proline content due to different varieties

| Varieties   | GR      | VI      | GE    | RW      | SW      | RW/SW   | T 50 % |
|-------------|---------|---------|-------|---------|---------|---------|--------|
| Anoman1     | 63.33 a | 51.67 c | 16.01 a | 0.07 a  | 0.35 a  | 0.13 a  | 2.99 a |
| Lamuru      | 57.00 ab| 16.56 a | 15.10 a | 0.08 a  | 0.30 a  | 0.10 a  | 3.40 b |
| Gumarang    | 65.00 ab| 53.33 c | 17.25 ab| 0.08 a  | 0.39 a  | 1.70 b  | 2.70 a |
| Srikandi    | 65.00 ab| 56.67 c | 19.46 ab| 0.10 a  | 0.43 ab | 1.68 b  | 2.68 a |
| Sukma       | 65.83 ab| 49.17 bc| 22.82 b | 0.10 a  | 0.40 ab | 1.92 c  | 2.92 a |
| Bisma       | 51.67 a | 45.00 b | 16.56 ab| 0.10 a  | 0.42 ab | 2.01 d  | 2.84 a |
| Laga ligo   | 61.67 a | 49.17 bc| 16.65 ab| 0.12 ab | 0.42 ab | 1.89 c  | 2.89 a |
| Arjuna      | 65.00 ab| 49.17 bc| 24.14 b | 0.11 ab | 0.35 a  | 1.71 b  | 2.88 a |
| NK Jmbo     | 73.33 b | 63.33 d | 15.77 a | 0.15 a  | 0.47 b  | 2.54 e  | 2.41 a |

From Table 2 it can be seen that Varieties show germination (GR), Vigor Index (VI), Growth Speed (GS), Dry Root Weight (DRW), and Dry Shoot Weight (DSW) Root-Shoot Ratio (RW/SW), and Tn 50% and different proline content, but the varieties did not show root weights (RW), Shoot weights (SW), growth equilibrium (GE), and different sprouts stress index (SSI). This will be more clearly seen in Figures 1 to 6 the average of viability, vigor and growth variables of V9 sprouts growth looks better than others, even on the 8th day observations of sprouts development of V9 even though they were treated with 20% PEG treatment but the sprouts that are produced tend to become normal sprouts. This fact indicates that among the nine corn varieties that were tested the V9 were predicted to be the corn varieties that were the most resistant to drought stress, followed by three other varieties namely Srikandi Kuning, Gumarang and Anoman I.

In contrast, Hybrids such as V9 have shoot dry weight and heavier roots under stress which are assumed to increase water absorption from soil profiles, especially from deep profiles. The poor growth rate of germination is shown by the V2, so that the low adaptability of the V2 is expected to be improved through organic material amendments using rice straw or biochar later, this study are in line with the results of research [16]. Where the response of resistant and sensitive varieties differed from maize germination by giving PEG, so it can be concluded that the adaptability to drought is greater by the V9 followed by V4 and the lowest adaptability of drought by the V2, so that the sensitivity of the V2 to drought is expected to be improved through the provision of organic amendments using rice straw or biochar later.

3.3. Identification of Interaction Effect.
The F Test results turned out that the interaction only affected GR, VI, RW/SW Ratio, and proline content. The average of the four germination parameters was presented in Table 3. From table 3 it was seen that there were differences in the responses of varieties to the administration of PEG.
From Table 3. above, it can be seen that there are differences in the interaction responses of varieties and PEG to germination, vigor index, root-canopy ratio and proline content of corn varieties that were tried. When not all of the varieties were gripped, they did not show differences in germination, but the vigor index, root-canopy ratio and proline content were noticeably different. Better vigor indices are found in V9 and V4 which are not significantly different from V3, V6 and V. The largest root-ratio ratio seen in V9 is different from all shown by V1. At the slightest stress, the strongest germination is shown by V9 which is not different from V3, V4, V5, V6, V7 and V8, but different from V1 and V2. The highest vigor index is found in V9 and V4. The highest root weight ratio of canopy weight was found in V9 varieties which were not different from V5 and V7. The highest Proline content during mild stress is also shown by V9 is not different from V4, V7 and V8. At the time of the greatest stress the strongest germination power, the largest vigor index, the highest root-canopy

Table 3. Average parameters of germination development due to differences in concentration PEG and corn varieties

| Treatments | Growth parameters |
|------------|-------------------|
|            | GR | VI  | RW/SW | Prolin |
| V1 P0      | 97,50 e | 87,50 hi | 0,188 bc | 0,575 gh |
| V2 P0      | 97,50 e | 87,50 h  | 0,172 bc | 0,446 ef  |
| V3 P0      | 100,00 e | 92,50 ij | 0,181 bc | 0,360 de  |
| V4 P0      | 95,00 de | 95,00 j  | 0,177 bc | 0,292 bc  |
| V5 P0      | 100,00 e | 87,50 hi | 0,154 b  | 0,274 bc  |
| V6 P0      | 100,00 e | 90,00 ij | 0,187 bc | 0,390 de  |
| V7 P0      | 100,00 e | 90,00 ij | 0,189 bc | 0,151 a   |
| V8 P0      | 97,50 e  | 87,50 hi | 0,202 bc | 0,342 cd  |
| V9 P0      | 100,00 e | 95,00 j  | 0,233 d  | 0,373 de  |
| V1 P1      | 92,50 d  | 67,50 g  | 0,188 b  | 0,332 cde |
| V2 P1      | 75,00 c  | 52,50 d  | 0,143 b  | 0,217 ab  |
| V3 P1      | 95,00 de | 67,50 g  | 0,201 cd | 0,257 bc  |
| V4 P1      | 97,00 de | 67,50 g  | 0,230 cd | 0,564 fgh |
| V5 P1      | 95,00 de | 60,00 ef | 0,253 de | 0,321 cd  |
| V6 P1      | 90,00 de | 65,00 fg | 0,197 bc | 0,338 cd  |
| V7 P1      | 85,00 de | 57,50 de | 0,346 de | 0,463 fg  |
| V8 P1      | 97,50 e  | 60,00 ef | 0,239 cd | 0,444 ef  |
| V9 P1      | 100,00 e | 70,00 gh | 0,365 e  | 0,602 gh  |
| V1 P2      | 0 a      | 0 a      | 0 a     | 0,574 gh  |
| V2 P2      | 0 a      | 0 a      | 0 a     | 0,377 def |
| V3 P2      | 0 a      | 0 a      | 0 a     | 0,628 h   |
| V4 P2      | 2,15 a   | 7,5 b    | 0,347 de | 0,904 i   |
| V5 P2      | 0 a      | 0 a      | 0 a     | 0,518 ef  |
| V6 P2      | 0 a      | 0 a      | 0 a     | 0,399 de  |
| V7 P2      | 0 a      | 0 a      | 0 a     | 0,375 cde |
| V8 P2      | 0 a      | 0 a      | 0 a     | 0,430 ef  |
| V9 P2      | 25,00 b  | 25,00 c  | 0,827 f  | 1,877 J   |

The number followed by the same letter in each row is not significantly different according to the LSD 0.05 test.
ratio and proline content were shown by V9 which was different from all other varieties and followed by V4 and V3, while the lowest proline content was shown by V2 (Lamuru Variety). Proline is one of the secondary metabolites produced by corn under stress [17]. He further added that plant secondary metabolites are various types of biologically active compounds that are essential for plant growth and development. Increases in metabolite compounds during drought stress have previously been reported in the Dendrobiu moniliforme plant [18]. Rhus tripartitum and Periploca [19]. [4] stated that plants synthesize various secondary metabolites when growth conditions are unfavorable. Fukami et al., (2018) cancel that secondary metabolites play an important role in protecting plants from the harmful effects arising from stress. Some secondary metabolites as non-enzymatic antioxidants participate in the stress response against oxidative stress.

4. Conclusion

All viability, vigor variables and growth characteristics of corn sprouts that were not given PEG were normal, at 10 % PEG concentration, viability, vigor and growth characteristics of corn sprouts were observed to be depressed with a value that continued to decline and at a concentration of PEG 20% all germination variables corn observed showed lower values, except the root-canopy ratio, where at the time of PEG 10 % the canopy ratio was seen to be greater than the corn sprouts that were not given PEG and 20 % PEG administration, on the contrary it was seen that the stress index was greater, the half-life for germination is longer and the proline content is increasing

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