Resistance Level of S1 Lines of Corn Plants to Drought Stress

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Abstract.

The formation of hybrid varieties by self-crossing the F2 population has been carried out, thus obtaining the first generation selfing line (S1). This research aims to determine the level of drought stress resistance of S1 lines of corn plants and the correlation between their characters and stress sensitivity index (SSI) value for each stress. The method used is an experimental method with field experiments. The experiment was carried out from March to June 2023 in Gumantar Village, Kayangan District, North Lombok Regency. The experimental design used was a randomized block design (RBD) in a split plot design with the main plot consisting of stress and normal treatments, while the sub plots were the S1 lines and the F2 population. The results showed that there were different levels of resistance in the S1 line. G27 has resistance with tolerant criteria, 13 lines are moderately tolerant, and 16 other lines are susceptible; Correlation criteria between characters vary with the SSI value in each stress and normal condition. Characters that are strongly correlated with the SSI value are chlorophyll A, total chlorophyll, harvest dry cob weight, and dry grain weight. The formation of S2 lines can be done using tolerant and moderately tolerant lines.

Keywords: *Stress, S1 Line, SSI, Drought and Resistance.*

I. INTRODUCTION

The increasing rate of land conversion which is not in line with the optimal amount of land for cultivation is the main reason for the importance of cultivating plants on dry land. The use of dry land for cultivation has been carried out and shows an increase in yields which is in line with the increase in farming efforts (Santoso et al., 2023). However, it cannot be denied that dry land has a major limiting factor, namely low water availability and this is exacerbated by climate change which results in an increase in the duration of drought and a reduction in the availability of water that can be absorbed by plants (Khatibi, et al., 2022). Based on this situation, commodities are needed that are resistant and have the potential to withstand drought stress, such as corn. The type of corn that is widely cultivated and has high yields is hybrid corn. Hybrid corn comes from the first offspring resulting from crossing pure lines which were formed through selfing (Rosliana, et.al., 2018). The formation of the first generation selfing line (S1) was carried out using the F2 population. The formation of hybrids in the F2 population is intended to obtain hybrid varieties that are suitable for dry land with the requirements of being drought resistant, high yielding, narrow leaf angle, and early maturity (Adriani, et. al., 2015).The F2 population is the result of hybridization between NK212 and NK7328 with Sinta Unram. The F2 population had its genetic variation components estimated and the dominant variation was greater than the genetic variation in leaf angle, harvest age and yield, so that the variety formed was a hybrid variety (Adeputri, et al., 2023). Selfing strains will show deep cross-depression or decreased stiffness due to self-crossing. Wulan, et.al., (2017) stated that selfing will cause the emergence of undesirable traits or poor appearance both in normal and stressful environments.

Efforts to obtain drought-resistant hybrid corn have been carried out by Khatibi, et al., (2022) and it was found that, of the six hybrid corn tested under drought stress, there were 2 drought-tolerant hybrid varieties, namely SC647 and KSC704 based on index estimates. Syauqi and Amzeri's (2023) research showed that drought stress that occurred in 20 corn genotypes tested showed long male and female flowering intervals (ASI) due to the slow initiation of female flowers/cob hairs. Meanwhile, the effect of deep cross depression on the S1 line resulting from crossing sweet corn and popcorn corn was carried out by Ullah, et.al., (2015) and obtained the character of the S1 line which had significant differences from its parents in the characteristics of plant height and leaf area, especially S1 sweet corn. The decrease in plant height that occurred in S1 sweet corn was 169.55 cm, while the decrease in leaf area was 44.92 cm2. S1 strains have

been tested for resistance to drought stress in dry land. The drought stress given is quite heavy because irrigation is stopped before flowering until harvest. The level of resistance can be determined through the value of the Stress Sensitivity Index based on the yield of each strain. Therefore, this study is intended to determine the level of drought stress resistance and the character that correlates with the value of the stress sensitivity index.

II. METHODS

The method used is an experimental method with field trialscarried out from March to June 2023 in Amor-Amor Hamlet, Gumantar Village, Kayangan District, North Lombok Regency, while analysis of chlorophyll levels was carried out at the Immunobiology Laboratory, Faculty of Mathematics and Natural Sciences, Mataram University. The experimental design used was a randomized block design (RAK) in a split plot design. As the main plot, stress and normal treatments were treated, while the S1 lines and F2 population were placed in subplots. Genotype S1 consists of 30 lines (G1-G30) and F2 populations in each main plot. Each main plot is repeated 2 times, as are the subplots. Therefore, 124 experimental units were obtained.

The material used is a collection of selfing seeds from the first generation (S1) of the F2 population. Implementation starts from land and seed preparation, planting, maintenance, observation and harvest. In practice, irrigation is divided into two conditions, namely normal and stressful conditions. Irrigation uses a leb system under normal conditions, while planting blocks that are treated with stress are only irrigated until the plants are about to emerge from the panicles (Ilmawan, et.al., 2018).The parameters observed were panicle exit age, ear hair exit age, Anthesis Silking Interval, number of leaves, leaf corner, leaf area, stem diameter, plant height, chlorophyll A, chlorophyll B, total chlorophyll, ear length, ear diameter, dry ear weight harvest, weight of harvested dry cobs, weight of 1,000 grain, and weight of dry grain.

Data analysis

The calculation of the drought stress sensitivity index value in Fischer & Maurer (1978) is calculated using the following formula:

$$SSI = \frac{1-\frac{Yc}{Yo}}{(1-\frac{Xc}{Xo})}$$

Information:

Yc = Average of grain weight/plants of a line under stress conditions
Yo = Average of grain weight/plants of a line under normal conditions
Xc = Average of grain weight/plants of all lines under stress conditions
Xo = Average of grain weight/plants of all lines under normal conditions

Drought tolerance criteria based on Tanjung, et.al., (2018) are tolerant if SSI < 0.5; Moderately tolerant if the value is 0.5 < SSI ≤ 1; susceptible if the SSI value is ≥ 1.

Correlation value analysis is calculated using the following equation:

$$r_{X1X2} = \frac{\sum(X_{1i} - \overline{X}_1)(X_{2i} - \overline{X}_2)}{\sqrt{\sum(X_{1i} - \overline{X}_1).\sum(X_{2i} - \overline{X}_2)}}$$

Information:

r = Correlation coefficient

Sarwono (2006) in Tanjung and Muliyani (2021) states the correlation coefficient criteria with the following classification:

0	=	There is no correlation
0-0.25	=	The correlation is very weak
>0.25-0.5	=	Correlation is sufficient
>0.5-0.75	=	Strong correlation
>0.75-0.99	=	The correlation is very strong
1	=	Perfect correlation

III. RESULTS AND DSSIUSSION

Drought stress is very urgent in the midst of widespread global warming due to the greenhouse effect which indirectly affects the ability of water to store soil for plants (Li & Lei, 2022; Ao et al., 2020). Drought stress simulations have been carried out in Gumantar Village with an average monthly temperature of 28.81ºC, monthly humidity of 71.8%, and average monthly rainfall of 2.1 mm/month. The average monthly temperature, air humidity and rainfall at the experimental location can be seen in Figure 1 below:

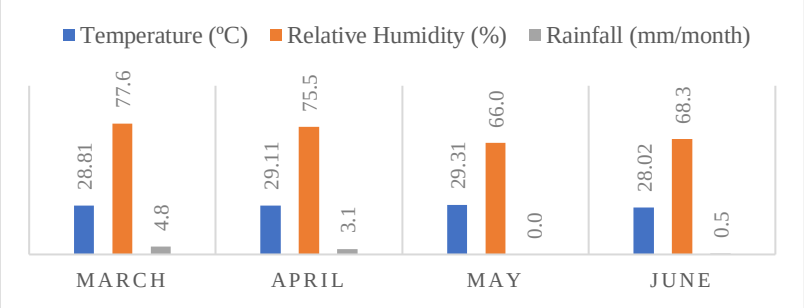

Fig 1. Average monthly temperature, humidity and rainfall at the Experimental Location

The figure above shows that the temperature at the experimental location is in the range of 28.02ºC-29.31ºC, the highest humidity with a percentage of 77.6% and rainfall of 0.5 mm/month-4.8 mm/month. Drought stress experiments were carried out on entisol type soil with a sandy clay texture, making it difficult to retain water available to plants because of the high sand fraction, namely 92-94% (Jaya et al., 2021).The experimental data have been analyzed and stress sensitivity index values were obtained, and the phenotypic correlation between the observed traits and the SSI value for each type of stress is presented in Table 3.1 and Table 3.2.

Stress Sensitivity Index (SSI)

The stress sensitivity index value and its criteria can be seen in Table 3.1 below:.

Table 3.1. Stress Sensitivity Index Values for S1 Lines and F2

Strains	SSI value	Criteria	Strains	SSI value	Criteria
G1	1.48	Susceptible	G17	1.37	Susceptible
G2	0.74	Moderately tolerant	G18	1.18	Susceptible
G3	1.34	Susceptible	G19	0.72	Moderately tolerant
G4	0.64	Moderately tolerant	G20	1.19	Susceptible
G5	0.94	Moderately tolerant	G21	1.13	Susceptible
G6	0.82	Moderately tolerant	G22	0.90	Moderately tolerant
G7	0.92	Moderately tolerant	G23	0.81	Moderately tolerant
G8	1.40	Susceptible	G24	0.79	Moderately tolerant
G9	1.24	Susceptible	G25	0.75	Moderately tolerant
G10	1.29	Susceptible	G26	0.83	Moderately tolerant
G11	1.37	Susceptible	G27	0.10	Tolerant
G12	1.01	Susceptible	G28	1.36	Susceptible
G13	0.92	Moderately tolerant	G29	1.15	Susceptible
G14	0.98	Susceptible	G30	1.27	Susceptible
G15	1.40	Susceptible	F2	0.10	Tolerant
G16	0.80	Moderately tolerant			

Table 3.1 shows the stress sensitivity index values for each S1 and F2 line using different criteria. The only lines with tolerant criteria are the S1.27 and F2 lines; moderately tolerant strains on G2, G4,G5, G6, G7, G13, G19, G22, G23,G24, G25, and G26; while strains with susceptible criteria were obtained in G1, G3, G8, G9, G1, G10, G11, G12, G14, G15, G17, G18, G20, G21, G28, G29, and G30

The criteria above are benchmarks for the resistance of a strain to drought stress, where the lower the SSI value of a strain, the more resistant it is to drought stress and vice versa. This statement is supported by Syauqi & Amzeri, (2023) that there is a decrease in the value of several characters in stressed lines compared to their parents. Apart from that, it is also stated that lines with tolerant criteria can be used as parents. Therefore, the level of tolerance can be used as a consideration in selecting lines that will be self-crossed in the next generation.

Phenotypic Correlation Between Characters and Stress Sensitivity Index Values

The phenotypic correlation between the observed characters and the stress sensitivity index value is presented in Table 3.2 to find out which characters are closely related to SSI. The results of the research carried out obtained different correlation coefficient values in stress conditions and normal conditions. Under stress conditions, the characteristics of chlorophyll A, total chlorophyll, harvest dry ear weight, and dry shell kernel weight had a significantly strong negative correlation; Cob length and weight of 1,000 seeds had a significant negative correlation with the SSI value. The other characters have no real correlation with the SSI value. Normal conditions only have one character that is significantly correlated, namely cob diameter, with a significant negative correlation.

Table 3.2. Phenotypic Correlation Coefficient Values Between Observed Characters and Stress Sensitivity Index Values in Two Types of Conditions

Observed Characters	Stress		Normal	
	SSI	Criteria	SSI	Criteria
Age of Anthesis	0.15	Very weak	-0.04	Very weak
Age of Silking	0.29	Enough	0.22	Very weak
Anthesis Silking Intervals (ASI)	0.25	Enough	0.22	Very weak
Leaf Corner	0.01	Very weak	0.03	Very weak
Plant height	-0.15	Very weak	-0.15	Very weak
Number of Leaves	-0.10	Very weak	0.33	Enough
Leaf Area	-0.33	Enough	-0.02	Very weak
Stem Diameter	-0.23	Very weak	-0.16	Very weak
Chlorophyll A	-0.63*	Strong	0.11	Very weak
Chlorophyll B	-0.35	Enough	0.16	Very weak
Total Chlorophyll	-0.56*	Strong	0.14	Very weak
Harvest Age	0.06	Very weak	-0.13	Very weak
Cob Length	-0.47*	Enough	-0.01	Very weak
Cob Diameter	-0.33	Enough	-0.49*	Enough
Harvested Dry Cob Weight	-0.51*	Strong	0.19	Very weak
Weight of 1,000 Grain	-0.40*	Enough	-0.07	Very weak
Weight of dry grain	-0.72*	Strong	0.21	Very weak

*)Significant at 5% level of significance

The correlation between characters and SSI values can determine the role of the observed characters on SSI values. Characters that show significance in each condition indicate a relationship or connection with SSI. The correlation coefficient values in Table 3.2 show that there are positive and negative correlations in the observed characteristics with SSI for both types of stress. Under stress conditions, various criteria were obtained, namely very weak (age of anthesis, leaf corner, plant height, number of leaves, stem diameter, and harvest age); enough (age of silking, leaf area, chlorophyll B, ear length, ear diameter, and weight of 1,000 seeds); strong (chlorophyll A, total chlorophyll, harvest dry ear weight, and weight of dry grain). Under normal conditions there are only very weak and sufficient criteria. Characters with very weak criteria are shown in all characters, except for the number of leaves and ear diameter with sufficient criteria.A positive coefficient value on the SSI value indicates that the observed character is directly proportional to the SSI, and vice versa.This shows that the characters have a real strong positive correlation in both types of stress conditions, the greater the value, the higher the SSI value. Meanwhile, if the negative correlation is significantly strong, the SSI value getting lower, which means the more resistant a strain is based on the observed characters.

Plant chlorophyll under stress conditions will be higher as a form of defense/tolerance against drought stress. This is in line with the statement Maintang et al., (2018) regarding chlorophyll which can be seen from the color of the leaves, the greener the leaves, the more chlorophyll there will be, and the decrease in chlorophyll levels in corn is caused by drought which stimulates the synthesis of leaf chlorophyll. Poudel (2023) stated that drought stress can cause a decrease in the value of the characteristics of the yield components, namely harvest dry ear weight, ear length, ear diameter, as well as weight of thousands of grain, and yield. So plants that have high yield and yield component values mean they have tolerance to water stress.Harvest dry cob weight is an important secondary character in determining the level of tolerance to drought stress, as in Fadhli et al., (2020) who obtained an increase in the harvest dry cob weight score under

stress conditions. This means that the increase in harvested dry cob weight will be directly proportional to tolerance to drought. Meanwhile, Efendi et al., (2017) stated that corn plants that are tolerant to water stress can be characterized by the persistence of yield under stress conditions.

IV. CONCLUSION

Based on the research results, it can be concluded that the level of resistance of the S1 lines is different. Most of the resistance levels are classified as susceptible and moderately tolerant. S1 strains with susceptible criteria are (G1, G9, G10, G11, G12, G14, G15, G, 17, G18, G20, G21, G28, G29, and G30); moderately tolerant (G2, G4, G5, G6, G7, G13, G16, G19, G22, G23, G24, G25, and G26); tolerant (G27 and F2); The observed characters had different correlation criteria with SSI, namely very weak (age of anthesis, leaf corner, plant height, number of leaves, stem diameter, and harvest age); enough (cob hair exit age, leaf area, chlorophyll B, ear length, ear diameter, and weight of 1,000 grain); strong (chlorophyll A, total chlorophyll, harvest dry ear weight, and dry grain weight).

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