Agrotech Journal
ATJ
Url: http://usnsj.com/index.php/ATJ
Email: editor.atj@usnsj.com

Growth and Production of Various Wheat Genotypes at Various PEG Concentration in Hydroponic

AUTHORS INFO

Muh. Farid Bdr
Hasanuddin University
Farid_deni@yahoo.co.id
+6281355041712

ARTICLE INFO

e-ISSN: 2548-5148
p-ISSN: 2548-5121
Vol. 3, No. 1, June 2018
URL: http://dx.doi.org/10.31327/atj.v3i1.521

Abstract

Wheat is a sub-tropical cereal that can be planted in the tropics, on the highland with altitude >1000 m asl. The development of wheat in the highlands compete with horticultural crops, so the creation of tropical wheat that is adaptive to lowland and drought tolerance is an alternative problem-solving. The aims of this study is to test the generation and to screen three type of mutant that is adaptive in lowland with high temperature. The study was conducted at Tamalanrea Jaya, Tamalanrea regency, Makassar province from May to August 2017. The research was conducted on hydroponic media in the plastic house (green house) at altitude <800 m asl with an average temperature of 28°C (morning) and an average temperature of 33°C (afternoon). The study was used split-plot design with the main plot of polyethylene glycol (PEG), ie 0%, 5%, 10%, and 15%; the plot was 15 wheat genotypes. The results showed that the addition of PEG concentrations at 5%, 10% and 15% decreased the crop yield by 35.91%, 55.63%, and 71.83%. Adaptive and potential genotypes developed in lowland with dry climatic conditions are genotype N.200 2.4.B.6 and genotype N.300 4.3.6

Keywords: hydroponic, lowland, polyethylene glycol, selection, wheat

A. Introduction

Wheat is an important cereal crop in the world due to has a strategic role in supporting food security and fullfilment food needs. According to Wittenberg (2004), wheat consumed about two billion people or 36% of the total world population. The need for wheat in Indonesia is met by importing from wheat-producing countries.

According to APTINDO (2016), Indonesia import for wheat in 2010 reached 5.2 million tons, 6.46 million tons in 2011 and 7.15 million tons in 2012. In 2013/2014, Indonesia's wheat imports reached 7.39 million tons (third world rank after Egypt 10.17 million tons and Algeria 7.49 million tons), while 2014/2015, Indonesia's wheat imports reached 7.49 million tons or ranked second after Egypt's of 11.06 million tons. Indonesia's wheat imports in 2015/2016 reached 8.10 million tons or ranked second after Egypt 11.50 million tons. The projection of Indonesian wheat imports for 2015/2016 was revised, previously imports in that period were estimated at only 7.8 million tons but because there was a purchase of wheat for animal feed consumption from Ukraine that reached to 300 thousand tons then the project rose to 8.10 million tons. Increased imports of wheat in Indonesia may be due to increased demand for Indonesian wheat consumption from 2012/2013, reached to 6.95 million tons; in 2013/2014 increased to 7.16 million tons; in 2014/2015 increased to 7.36 million tons (FAO, 2015).

Increased imports of wheat that reduce the country's foreign exchange must be overcome by creating a national food diversification program through the development of wheat crops in Indonesia. The challenges in the development of wheat in Indonesia from upstream to downstream subsystems are not yet fully controlled by farmers and field officers. Moreover, wheat planted in lowland with a minimum height of 800m above sea level will compete with vegetable commodities and highland fruits. This is caused wheat not to become a priority commodity in the highlands. Therefore, it is needed to undertake various forms of domestic wheat development activities through the application of cultivation technology in accordance with agroclimate conditions in Indonesia and to seek an alternative strategy in the lowlands (Sovan, 2002)

The development of lowland wheat planted on dry land faced the inability to compete with rice and maize commodities. Indonesia has widely dry land, with an estimated 60.7 million hectares or 88.6% of the land area, while the paddy field area is only 7.8 million hectares or 11.4%. Data of 2012, Indonesia has dry land about 148 million ha (78%) and wetlands of 40.20 million ha (22%) of the total 188.20 million ha agriculture land area (National Coordination Agency for Spatial Planning, 2012) . Location of dry land is prospectly for the cultivation of wheat for the future.

The development of lowland wheat consequently lead to the high temperature- stressed condition which then affects the decreased pollen viability and crop yield. Barnabas, Jager, & Feher, (2008) explained that the decline in fertility of pollen and the emptiness of panicles caused by disruption of the process of spore and gamete formation in plants. Some of the proteins that play a role in the process are denatured by the influence of high temperature. Enviroment temperature is one of difficult factor to control (Mustafa, Syukur, Sutjahtjo, & Sobir, 2017). Modified cultivation techniques may reduce losses caused by high temperature; However, it is only temporary and less effective because it must be done every growing season and is costly, so the use of tolerant varieties is a more effective solution (Liebisch, Max, Heine, & Horst, 2009). The first stage are screening and identification of tolerant genotypes (Mustafa *et al.*, 2017). The identification of resistant genotypes is largely determined by selection and methods. The increase in temperature occurs due to the effects of drought, yet, the most appropriate selection agent is polyethylen glycol (PEG). This study aimed to select the genotype of mutant derived from mutated wheat using gamma rays that are tolerant to lowland with high temperatures.

B. Methodology

The study was conducted in Tamalanrea Jaya, Tamalanrea Regency, Makassar Province from Mei to August 2017. The study was done by using Hydoponic media in the gase house at 800 m asl with average temperature 30-37 C. The study used split-plot design with the main plot of polyethylene glycol (PEG) are 0%, 5%, 10%, and 15%; plot used are 15 wheat genotypes such as :g1 =N.350 3.6.2 , g2 =N.300 3.6.1, g3 = N.350 3.1.3, g4 = N.350 3.2.2, g5 = N.250 4.5.2, g6 = N.350 3.1.4, g7= Munal 200 1.7.1, g8= N.250 4.6.2, g9= N.350 3.8.9, g10 = N.200 2.4.B.6, g11 = N.200 2.5.2,g12 = N.200 2.3.3, g13= N.300 4.3.6, g14 = NIAS (comparation variety), dan g15 = MUNAL (comparation variety).

Seedling with a height of 10 cm were transferred to charcoal + chocofit media on net pots with flannel axis at hydroponic installation. Hydroponics Media was added with AB Mix with the concentration of 1000 ppm. PEG treatment was aplied 2 weeks after planting with the concentration of 0%, 5%, 10%, and 15%. The pH of the solution was adjusted at 6.5; PH measurements were performed using pH meters. Volume of water for one treatment installation was 250 liters. Subsequent maintenance was done by adding nutrient solution daily according to the amount of water volume decrease from 150 liters; to maintain PEG concentration in the media during treatment.

The parameters observed in this study were plant height, the percentage of empty floret, number of spikelet per panicles, the period of seed filling (Seed Replenishment), yield per clump, and stress tolerant index (ITC). The ITC is calculated based on seed production using the formula proposed by Fischer & Maurer (1978):

$$ITC = (Ypi \times Ysi)/Yp^2$$

Where:

Ysi: The average of a genotype suffered drought stress

Ypi: The average of a genotype without drought stress

YP: The average of the total of genotype that not suffered drought stress

The criterion for to determine the tolerance level for drought stress is; the value of $ITC \leq 0.5$=sensitive, $0.5 < ITC \leq 1.0$ = medium, and $ITC > 1.0$ = tolerant.

C. Result and Discussion

1. Number of spikelet and the period of seed filling (Seed Replenishment)

Statistical analysis showed that the genotype had a very significant effect on the number of spikelets, plant height, and seed filling duration. The results of LSD Test in Table 1 show that the genotype g10 (N.200 2.4.B.6), g13 (N.300 4.3.6) and g7 (M.200 1.7.1) suggest the highest crop yield and significantly different from the comparison varieties/ variety Nias (a) and Munal (b), whereas for the duration of filling the seeds only g13 (N.300 4.3.6) gives the oldest filling time and is significantly different from the comparison varieties of Nias (a) and variety Munal (b). Treatment g1 (N.350 3.6.2), g2 (N.300 3.6.2), g3 (n.350 3.1.3), g4 (N.350 3.2.2), g7 (M.200 1.7.1) and g10 (N.200 2.4.B.6) show the highest number of spikelet and significantly different from the comparison varieties of Nias (a) and munal (b).

Table 1. The average number of spikelet and the duration of seed filling of several wheat genotypes at different PEG concentrations.

Genotype	Plant height		Period of seed filling		Number of spikelet	
g1 (N.350 3.6.2)	23.64		35.88		9.34	ab
g2 (N.300 3.6.1)	28.65		35.43		9.61	ab
g3 (N.350 3.1.3)	31.37	a	33.96		9.68	ab
g4 (N.350 3.2.2)	28.18		36.55		9.49	ab
g5 (N.250 4.5.2)	25.63		35.02		8.58	
g6 (N.350 3.1.4)	30.25		37.74	b	8.92	b
g7 (M. 200 1.7.1)	31.85	ab	36.56		9.48	ab
g8 (N.250 4.6.2)	28.30		36.81		8.49	
g9 (N.350 3.8.9)	22.43		33.48		8.97	b
g10(N.200 2.4.B.6)	32.62	ab	35.95		9.26	ab
g11 (N.200 2.5.2)	28.47		34.77		8.91	b
g12 (N.200 2.3.3)	23.89		34.40		8.09	
g13 (N.300 4.3.6)	31.74	ab	39.11	ab	8.95	b
g14 (Nias) (a)	28.19		35.45		8.50	
g15 (Munal) (b)	28.98		34.25		8.08	
LSD	2.51		2.57		0.74	

Note: The numbers followed by the same letters in the sub plot column (a, b) indicates significantly different from the comparison varieties of variety Nias (a) and Munal (b) on the LSD test at α = 0.05.

The treatment with different PEG concentrations to the wheat mutants may show different plant responses even though they are placed on the same plant medium. Treatment of PEG concentrations in wheat crops may have water deficiency, cell damage, turgor loss, closed stomata, early reaping on plant leaves, disturbed gas exchange and lead to not optimum growth and production of wheat mutants. This is because the ability of PEG to hold water components so that enough water are enable for plants for metabolism activities, thus impact on growth and development of the plants. The parameter affected by the plant experiencing drought stress is plant height, the number of spikelet, the duration of seed filling and the percentage of empty florets; these significantly correlated to the production. Based on the results obtained from the observations with treatment without drought stress; treatment of PEG concentration at 5%, 10%, and 15%; the wheat mutant showing the best response with the highest yield was the wheat mutant g10 (N.200 2.4.B.6)

The high performance of wheat stems is very important in determining the high production genotype as it affects the vulnerability of the plant to fall. The height of the wheat crop has decreased with increasing level of PEG concentration. The decrease of plant height is caused by the lack of water uptake by plant so that the metabolic process of the plant does not occur maximally, this may lead to a lack of energy generated for cell division, premature leaf aging and stunted growth of plant height; PEG in the hydroponic solution media results in the inhibition of root formation of plants since PEG is able to attach to the roots of wheat and thereby inhibiting the water uptake by the plants hence affects the formation of roots is not maximal. Salisbury & Ross (1992) revealed that high concentrations of PEG inhibit the division and development of the cell.

2. Number of Productive Tillers

Statistical analysis shows that the interaction between genotypes with PEG concentrations had a very significant effect on the percentage of empty florets. LSD test in table 2 shows that g8 (N.250 4.6.2) gives the highest number of productive tillers at treatment with PEG concentrations of 0% and 5% and is significantly different from the comparison varieties of Nias (a) and Munal (b), whereas g6 (N. 3503.1.4) shows the lowest percentage of empty florets at 10% PEG and 15% PEG concentrations and significantly different on the comparison varieties of variety Nias (a) and Munal (b).

Table 2. Percentage of empty florets of various wheat genotypes on different PEG concentrations.

Genotype	PEG Concentration				Average
	P_0 (0%)	P_1 (5%)	P_2 (10%)	P_3 (15%)	
g1 (N.350 3.6.2)	59.13	71.16	84.76	88.46	75.88
g2 (N.300 3.6.1)	61.59	72.30	74.97	75.31	71.04
g3 (N.350 3.1.3)	66.46	73.92	79.70	81.66	75.43
g4 (N.350 3.2.2)	62.52	77.00	81.00	83.64	76.04
g5 (N.250 4.5.2)	70.63	72.15	75.49	78.01	74.07
g6 (N.350 3.1.4)	54.92 ab	60.52	62.03 ab	62.84 ab	60.08
g7 (M. 200 1.7.1)	35.22 ab	65.62	71.31	72.14	61.07
g8 (N.250 4.6.2)	49.22 ab	54.32 ab	63.97	69.58	59.27
g9 (N.350 3.8.9)	66.43	68.69	70.19	74.46	69.94
g10(N.200 2.4.B.6)	54.99 a	64.38	62.06 a	65.18 ab	61.65
g11 (N.200 2.5.2)	61.03	72.21	77.16	81.60	73.00
g12 (N.200 2.3.3)	63.81	70.74	73.08	78.12	71.44
g13 (N.300 4.3.6)	45.66 ab	59.45 b	59.93 ab	60.21 ab	56.31
g14 (Nias) (a)	68.88	69.46	72.46	79.47	72.57
g15 (Munal) (b)	65.85	70.31	72.08	76.95	71.30
Average	59.09	68.15	72.01	75.18	
LSD		7.79			

Note: The numbers followed by the same letters in the sub plot column (a, b) indicates significantly different from the comparison varieties of variety Nias (a) and Munal (b) on the LSD test at α = 0.05..

The number of spikelet is a vegetative parameter in wheat plants that can be easily observed and is related to the production of wheat crops. The correlation regression test showed that the number of spikelet has no effect on the production yield with the value of 0.01. It is caused by the slight amount of food and the assimilates which will fill the spikelet so that the number of filled spikelet is less than the number of empty spikelet. This is supported by the opinion of Wahid, Gelani, Ashraf & Foolad, (2007) which states that wheat suffered drought stress (deficit water) impact on assimilating forming process; that will be inhibited as the filling of floret in spikelet is not optimal.

3. Yield

Statistical analysis shows that the interaction of genotype treatment with PEG concentration had a very significant effect on the crop yield. The LSD test in Table 3 shows that genotype 10 (N.200 2.4.B.6) has the highest production and is significantly different from the comparison varieties of variety Nias (a) and Munal (B) and is tolerant to all PEG concentrations.

Table 3. Production of various wheat genotypes on different PEG concentrations.

Genotype	PEG Concentration											Average		
	P_0 (0%)		P_1 (5%)			P_2 (10%)			P_3 (15%)					
g1 (N.350 3.6.2)	1.26	ab	0.57		S	0.24		S	0.20		S	0.57		S
g2 (N.300 3.6.1)	0.95		0.63		S	0.53		S	0.33		S	0.61		S
g3 (N.350 3.1.3)	0.88		0.59		S	0.35		S	0.19		S	0.50		S
g4 (N.350 3.2.2)	1.23	ab	0.58		S	0.39		S	0.28		S	0.62		S
g5 (N.250 4.5.2)	0.84		0.62		S	0.43		S	0.27		S	0.54		S
g6 (N.350 3.1.4)	2.12	ab	1.36	ab	T	1.18	ab	T	0.58		M	1.31	ab	T
g7 (M. 200 1.7.1)	1.88	ab	0.93	a	M	0.50		S	0.40		S	0.93	ab	M
g8 (N.250 4.6.2)	2.72	ab	1.90	ab	T	1.00	ab	T	0.60		M	1.60	ab	T
g9 (N.350 3.8.9)	0.71		0.64		S	0.51		S	0.40		S	0.57		S
g10(N.200 2.4.B.6	2.58	ab	1.70	ab	T	1.36	ab	T	0.88	ab	T	1.63	ab	T
g11 (N.200 2.5.2)	1.16		0.83		S	0.47		S	0.34		S	0.70		S
g12 (N.200 2.3.3)	1.03		0.81		S	0.59		S	0.34		S	0.69		S
g13 (N.300 4.3.6)	2.19	ab	1.37	ab	T	0.91	ab	M	0.70	ab	M	1.29	ab	T
g14 (Nias) (a)	0.81		0.46		S	0.45		S	0.31		S	0.51		S
g15 (Munal) (b)	0.82		0.65		S	0.45		S	0.24		S	0.54		S
Average	1.42		0.91			0.63			0.40					
LSD					0.37									

Note: The numbers followed by the same letters in the sub plot column (a, b) indicates significantly different from the comparison varieties of variety Nias (a) and Munal (b) on the LSD test at α = 0.05; S: Sensitive, M: Medium, T:Tolerance

The condition of drought stress in wheat crop can lead to the faster flowering and harvest ages, of which the early cross flowering and harvest time resulted in the duration of the seed filling which become not optimal and the decrease of seed production per panicle. This is the mechanism of plants in response to the drought stress so that flowering and harvesting age become faster. According to Stapper & Fischer (1985), during the seed filling process the higher temperature affects the faster development of wheat; although the plants are optimally managed, it can decrease to 4% for temperature rise of 1°C at high temperatures due to the seed filling period become very short.

One response to wheat crops suffered drought stress is the increase in the percentage of empty florets. The percentage of empty florets is the number of empty space found in panicles as the accumulation of assimilates that will fill the panicle is not sufficient, this is due to the not optimal process of photosynthesis so that the assimilate is formed slightly, and in the end the percentage of empty floret is greater than the number of seeds per panicle. The percentage of empty florets in wheat plants is an indicator that wheat crops are tolerant or not to the stress condition. Simmons; Anderson; in Akbar (2016) stated that too low or too high temperature resulting in the number of sterile florets that cannot be fertilized.

The treatment of PEG in the hydroponic solution will hold water component, impacts water uptake by plants and thereby causing drought. According to Levitt, (1980) drought stress is due to a lack of water supply from the root zone and excessive water demand by leaves; where the period of evapotranspiration exceeds the length of water uptake by plant roots. This will impact on the decline in photosynthetic activity, so the amount of assimilates produced decreases and causes the formation of panicles and the filling of seeds will decrease. Oertli (1985) states that the polyEthylene Glycol Compound is able to stimulate the drought stress condition by decreasing the potential of water present in the root environment and resulting in the decrease of hydrostatic pressure in the cell. This is in line with the opinion by Taiz & Zeiger (2002), that drought stress affects plant morphology and decreases crop yield.

D. Conclusion

The genotype of wheat mutant that potentially adaptive with high yield in hydroponic media at the treatment of without PEG, 5%, 10% and 15% PEG concentration, are N.250 4.6.2 and N.200 2.4.B.6. The characters of seed filling and the percentage of empty floret have a positive correlation to the crop yield.

E. References

Akbar, A. F. (2016). Evaluasi Segregan Gandum (*Triticum aestivum* L.) Generasi F5 Hasil Persilangan Convergent Breeding Adaptif Dataran Menengah. (Unpublished Thesis). Hasanuddin University. Makassar.

Asosiasi Produsen Terigu Indonesia (ASTINDO). (2016). Asosiasi Produsen Terigu Indonesia. Available at *http://bataviase.co.id/node/436332.* Accessed on December 2017.

Barnabas, B., Jager, K., & Feher, A. (2008). The Effect of Drought and Heat Stress on Reproductive Processes in Cereals. *Plant Cell Environ,* 31, pp. 11–38.

FAO. (2015). FAO Statistics. Available at *http://FAOstat.fao.org*. Accessed on October 2017.

Fischer, R. A. & Maurer, R. (1978). Drought Resistance in Spring Wheat Cultivars: I. Grain Yield Responses. *Aust. J. Agric. Res.*, 29, pp. 897-912.

Levitt, J. (1980). *Response of Plants to Environmental Stresses. Water, Radiation, Salt, and Other Stresses*. New York: Academic Press.

Liebisch, F., Max, J. F. J., Heine, G., & Horst, W. J. (2009). Blossom-end Rot and Fruit Cracking of Tomato Grown in Net-Covered Green Houses in Central Thailand can Partly be Corrected by Calcium and Boron Sprays. *J. Plant Nutr. Soil Sc.*, 172, pp. 140-150.

Mustafa, M., Syukur, M., Sutjahjo, S. H., & Sobir. (2017). Inheritance of Fruit Cracking Resistance in Tomato (*Solanum lycopersicum* L.). *Asian J. Agric. Res., 11*(1), pp. 10-17.

National Coordination Agency for Spatial Planning. (2012). Buletin Tata Ruang BKSRN, Badan Kordinasi Penataan Ruang Nasional. Menata Kawasan Hutan dan Mempertahankan Lahan pertanian. Available at *http://www.pu.go.id.* Accessed on January 2018.

Oertli, J. J. (1985). The Response of Plant Cells to Different Forms of Moisture stress. *Jurnal of Plant Physiology,* 121, pp. 295–300.

Salisbury, F. B. & Ross, C. W. (1992). *Plant Physiology*. New York: Wadsworth Publishing Co.

Sovan, M. (2002). Penanganan Pasca Panen Gandum. Paper Presented at the Coordination Meeting of the Development of Wheat. Pasuruan, Jawa Timur, 3-5 September 2002. Unpublished. Jakarta: Direktorat Jenderal Bina Produksi Tanaman Pangan.

Stapper, M. & Fischer, R. A. (1985). Genotype, Sowing Date and Plant Spacing Influence on High-Yielding Irrigated Wheat in Southern New South Wales. II Growth, Yield and Nitrogen Use. *Aust. J. Agin Res*, 41, pp. 1021-1041.

Taiz, L. & Zeiger, E. (2002). *Plant physiology*. Third Edition. Sunderland, Massachusetts: Sinauer Associates Inc. Publisher.

Wahid, A., Gelani, Ashraf, & Foolad. (2007). Heat Tolerance in Plants: An overview. *Journal of Environmental and Experimental Botany*, 61, pp. 199–223.

Wittenberg, H. (2004). The Inheritance and Molecular Mapping of Genes for Post-Anthesis Drought Tolerance (PADT) in Wheat. (Published Dissertation). Martin Luther Universitat. Available at *https://www.researchgate.net/profile/Khaled_Salem2/publication/231814909_The_Inheritance_and_Molecular_Mapping_of_Genes_for_Post-anthesis_Drought_Tolerance_PADT_in_Wheat/links/0fcfd5070e842bb489000000/The-Inheritance-and-Molecular-Mapping-of-Genes-for-Post-anthesis-Drought-Tolerance-PADT-in-Wheat.pdf.*