



Yield Evaluation and Selection of M6 Wheat Mutant adaptive to Medium Land

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Abstract

Wheat is a sub-tropical plant that can adapt well at altitudes of 1000 - 3000 m above sea level and requires relatively low temperatures. At this height, wheat crops in Indonesia are unable to compete with horticultural crops with higher economic value. This causes national wheat production to be very low and results in high wheat imports. Therefore, wheat varieties are needed that can grow and develop in Indonesia in the low to medium plains. The study aimed to test the adaptive mutant population descent in the middle plains to prepare multi-location tests and release of varieties. The benefit of this research is obtaining potential strains from high-temperature adaptive wheat mutants in the lowlands. This research was conducted using a randomized block design with three replications. The treatment consisted of 16 M6 Wheat mutants and four comparative varieties. The results showed that the genotypes of wheat mutants that had high production in M6 propagation in the central plains were N 350 3.7.1 (2.74 t. ha⁻¹), N 350 3.6.2 (2.33 t.ha⁻¹) and N 350 3.1.3 (2.26 t.ha⁻¹). Characters that have high heritability values on M6 Number of stomata, chlorophyll index, plant height, number of tillers, productive tillers, rate of seed filling, panicle length, number of seedlings, empty percentage of florets, hollow seed weight, 1000 seed weight, and production

Keywords: wheat, mutant, selection, medium land, heritability

A. Introduction

Agricultural sector development efforts are always faced with a dynamic domestic and international environment. Therefore, agriculture in Indonesia must have a comparative advantage as a basis for building national and international competitive advantages, so that it can improve the welfare of the community in a sustainable manner (Basir, 2001). The increase in population and per capita income of the Indonesian people has led to the rise in food demand in terms of quantity, type and quality. The diversification program undertaken by the Indonesian government has succeeded in gradually reducing rice consumption, but alternative foods that are widely used by the community are still limited to foods made from imported raw materials such as wheat. The need for wheat in Indonesia, which continues to increase every year encourages the government to meet these needs by introducing.

Wheat crops are only developed in sub-tropical regions because they are plants that can adapt well at altitudes of 1000 - 3000 m above sea level and require relatively low temperatures. At this height, wheat crops in Indonesia are unable to compete with horticultural crops with higher economic value. This causes Indonesia to be the second-largest wheat importer in the world after Egypt. The need for wheat in Indonesia is 100% met from imports, the United States Department of Agriculture (USDA) estimates that Indonesia's wheat imports in 2015-2016 reached 8.10 million tons, up about 8% from the previous year (2014) of 7.48 million tons. With so many imports, Indonesia is the world's second-largest wheat importer after Egypt, which reached 11.50 million tons. Even in 2017, Indonesian wheat imports have reached 11.6 million tons with an import value of US \$ 2,771,792,426 (Alnopri, 2004).

The increase in wheat imports that drain the country's foreign exchange must be overcome by a food diversification program by developing climate-appropriate wheat crops in Indonesia. Based on this fact, it is necessary to explore the potential of wheat plants that can grow and develop in Indonesia. If this is not anticipated, Indonesia will become the world's number one wheat importer after Egypt and Brazil.

The problem faced in the effort to develop wheat in the middle and lowlands is the differences in the suitability of the agro-climate conditions which will make the wheat in a high-temperature grip condition. Althuhaish, Miftahdin, Trikoesoemaningtyas, & Sudirman (2014) reported that the climate in Indonesia for the highlands is very different from the low or medium plains. Wheat is cultivated in high-temperature stress conditions with an average temperature ($> 29^{\circ}\text{C}$) can inhibit plant growth, the number of tillers and reduce yield and yield components (Althuhaish *et al.* 2014). Potential mutants developed in the lowlands that produce higher production than comparable varieties are N.200 2.5.2, N.250 4.6.2 and N.350 3.6.2 (Dolferus, Xuemei, Richard, 2011).

The research aims to test the adaptive mutation populations of lowland mutants to proceed to the multi-location test and release of varieties. The benefit of this research is obtaining potential strains from high-temperature adaptive wheat mutants in the lowlands. This will help in the supply of foodstuffs from wheat which is highly favoured by all members of the community, both in villages and in cities. Therefore, the development of wheat will support a national program to increase food diversification that will reduce dependence on rice, reduce the volume of wheat imports so that the country's foreign exchange increases.

B. Methodology

This research is a test of descent, selection, and evaluation for multi-location test preparation and adaptation of several genotypes of wheat mutants that are potentially developed and adaptive in the lowlands. Research using the Pedigree selection method using genetic material from the results of previous studies that have been irradiated. The design used was a Randomized Block Design with selected mutant genotypes as treatment. The plot size used was 3m x 5m with three replications. The parameters observed were plant height, number of tillers, number of productive tillers, panicle length, number of spikelets, number of empty spikelets, the weight of seeds per

panicle, the weight of 1000 grains, leaf chlorophyll content, number of stomata, and productivity. Data analysis was performed by analysis of variance followed by BNT0.05 test. To find out the relationship between characters, regression and correlation studies were carried out, while the genetic diversity of mutant genotypes was carried out by heritability analysis. To find out the relationship between characters, regression and correlation analyses were carried out, while the genetic diversity of mutant genotypes was carried out by heritability analysis.

C. Results and Discussion

1. Results

Table 1 propagation of M6 in the stomata number parameter shows that (N 350 3.6.2) g1 has the best average compared to all genotypes and comparison varieties with a value (9.56). The stomata density parameter shows that (N 350 3.13) g3 has the best average (47.55 n.cm⁻²). Whereas in the Chlorophyll index shows that (N 350 3.7.1) g13 has the best average value compared to the comparative variety (Munal) namely (779.49)

Tabel 1. Average Number of Stomata, Stomata Density and Chlorophyll Index of several M6 wheat genotypes in medium land

Genotype	Jumlah Stomata	Kerapatan Stomata	Indeks Klorofil
(g1) N 350 3.6.2	9,56 abcd	43,68 bd	776,39 d
(g2) N 300 3.6.1	5,89	37,04 d	766,64
(g3) N 350 3.1.3	8,56 abcd	47,55 bcd	771,95
(g4) D 200	8,56 abcd	38,70 d	774,99
(g5) N 350 3.1.4	7,11 a	35,39 d	767,39
(g6) N 250 2.5.1	7,00 a	34,83 d	767,35
(g7) M 200 1.7.1	7,89 bd	42,57 d	775,15
(g8) N 250 4.6.2	6,56 a	32,62	767,87
(g9) S 300 8.3.1	7,67 d	38,15 d	768,68
(g10) S 6.4.1	8,89 abcd	42,57 d	772,37
(g11) S 300 7.9.1	7,78 bd	39,26 d	773,85
(g12) S 300 2.1	7,44 d	33,17 d	769,16
(g13) N 350 3.7.1	8,78 abcd	43,57 bd	779,49 d
(g14) N 200 2.4.B.6	8,11 abd	34,83 d	763,50
(g15) N 200 2.5.2	7,00 a	40,36 d	774,54
(g16) N 200 2.3.3	6,33 a	31,52	770,22
(g17) Dewata (a)	6,89	39,30	767,56
(g18) Selayar (b)	6,67	34,28	771,46
(g19) Nias (c)	7,22	35,94	770,91
(g20) Munal (d)	4,89	24,33	760,33
NP BNT 5%	1,11	8,74	15,25

The numbers followed by the same letter in the column (abcd) mean very different from the comparative varieties of Dewa (a), Selayar (b), Nias (c), and Munal (d) at the BNT test level = 0, 05

Plant Height parameters in table 2 show that (N 350 3.6.2) g1 has the best average value compared to comparative varieties (selayar) 70.53 cm) whereas the number of tillers and productive tillers shows that (N 350 3.7.1) g13 has the best value compared to all comparative varieties, namely (7.27 number of tillers) and (6.47 productive breeds).

Table 2. Average plant height, number of tillers and tillers productive of several M6 wheat genotypes

Genotype	Plant height		Number of tillers		Number of Tillers Productive	
(g1) N 350 3.6.2	70,53	b	7,07	abcd	4,80	abcd
(g2) N 300 3.6.1	58,33		4,07		3,13	
(g3) N 350 3.1.3	68,93	b	7,13	abcd	5,27	abcd
(g4) D 200	69,07	b	5,67	bcd	4,40	abcd
(g5) N 350 3.1.4	64,00		4,40		3,40	d
(g6) N 250 2.5.1	58,93		4,87		3,67	d
(g7) M 200 1.7.1	70,40	b	6,60	abcd	3,20	
(g8) N 250 4.6.2	62,10		5,07		3,87	d
(g9) S 300 8.3.1	49,80		4,53		2,33	
(g10) S 6.4.1	62,80		6,67	abcd	5,80	abcd
(g11) S 300 7.9.1	66,87		5,80	bcd	4,13	abcd
(g12) S 300 2.1	60,20		5,00		2,07	
(g13) N 350 3.7.1	70,03	b	7,27	abcd	6,47	abcd
(g14) N 200 2.4.B.6	53,63		4,87		3,20	
(g15) N 200 2.5.2	60,93		5,93	abcd	4,13	abcd
(g16) N 200 2.3.3	57,93		4,93		3,40	d
(g17) Dewata (a)	60,80		4,73		3,20	
(g18) Selayar (b)	57,80		4,20		3,53	
(g19) Nias (c)	64,17		4,53		3,53	
(g20) Munal (d)	61,20		4,27		2,47	
NP BNT 5%	10,13		1,13		0,78	

The numbers followed by the same letter in the column (abcd) mean very different from the comparative varieties of Dewa (a), Selayar (b), Nias (c), and Munal (d) at the BNT test level = 0, 05

The development of the number of productive tillers is primarily determined by environmental factors, especially air temperature, the higher the air temperature tends to slow the growth of the number of productive tillers. This is consistent with the results of research Handoko (2007) that the development of the number of tillers is strongly influenced by the air temperature. The number of tillers in wheat plants is significant, especially the number of productive tillers where the number of productive tillers is the number of tillers so that the number of productive tillers is positively correlated. This is consistent with the opinion of Bowden et al., (2007) that the number of panicles/number of tillers, the correlation value is closest to 1.0 compared to other vegetative parameters.

In the M6 propagation activity (table 3), the flowering age parameters showed that (N 350 3.1.4) g5 had the fastest average flowering age compared to other genotypes (63.00 hst). For harvest age parameters, (N 200 2.5.2) g15 has the most rapid average harvest age (92.00 hst). Whereas the parameter of seed filling rate shows (N 200 2.5.2) g15 has the fastest average speed filling rate compared to all genotypes and comparison varieties, namely (24.33 HST).

The speed of flowering in wheat plants is influenced by the physiological conditions of the plants which are affected by the temperature of the surrounding environment. If the temperature is too high, the age of wheat flowering is faster than in the middle to highlands. This is consistent with the opinion of Glover (2007) that the flowering behaviour and flowering of plants are closely related to the physiological conditions of plants and the influence of environmental factors that specifically include the impact of intensity and duration of irradiation, control of temperature, and water availability on plant growth

environments. The mechanism of flowering age as one of the wheat adaptation efforts is also strengthened by Dolferus (2011) opinion which states that the adjustment of flowering time is an essential mechanism of adaptation of wheat plants to the desired environmental conditions because it can result in avoidance of abiotic stresses, especially heat stress in specific environments.

Table 3. Average Flowering Day, Harvest Day, and Seed Filling Rate for several M6 wheat genotypes

Genotype	Flowering Day		Harvest Day		Seed Filling Rate	
(g1) N 350 3.6.2	64,33	abcd	100,33	abcd	36,67	cd
(g2) N 300 3.6.1	65,33	abcd	97,33	abcd	34,00	bcd
(g3) N 350 3.1.3	68,00	abcd	103,67	abcd	35,00	cd
(g4) D 200	68,67	abcd	92,67	abcd	35,33	cd
(g5) N 350 3.1.4	63,00	abcd	96,00	abcd	32,67	abcd
(g6) N 250 2.5.1	64,33	abcd	94,67	abcd	30,00	abcd
(g7) M 200 1.7.1	65,33	abcd	92,33	abcd	28,67	abcd
(g8) N 250 4.6.2	65,67	abcd	94,00	abcd	29,00	abcd
(g9) S 300 8.3.1	63,67	abcd	95,33	abcd	32,33	abcd
(g10) S 6.4.1	64,00	abcd	95,33	abcd	29,67	abcd
(g11) S 300 7.9.1	64,00	abcd	95,00	abcd	30,67	abcd
(g12) S 300 2.1	65,33	abcd	100,00	abcd	33,67	bcd
(g13) N 350 3.7.1	63,67	abcd	94,33	abcd	31,00	abcd
(g14) N 200 2.4.B.6	65,67	abcd	95,33	abcd	27,67	abcd
(g15) N 200 2.5.2	66,33	abcd	92,00	abcd	24,33	abcd
(g16) N 200 2.3.3	67,67	abcd	95,00	abcd	30,33	abcd
(g17) Dewata (a)	67,67		98,67		30,00	
(g18) Selayar (b)	65,00		95,67		31,33	
(g19) Nias (c)	65,33		97,33		33,67	
(g20) Munal (d)	65,67		105,33		40,00	
NP BNT 5%	4,50		10,54		3,48	

The numbers followed by the same letter in the column (abcd) mean very different from the comparative varieties of Dewa (a), Selayar (b), Nias (c), and Munal (d) at the BNT test level = 0, 05

Indicator of wheat plants approaching the time of harvest, ie panicles begin to change colour to yellow to get the stem. This is following the opinion of Wiyono (1980) stating that if 20% of the panicle is fully cooked, where the grain (seeds) of wheat are hard enough when massaged by hand, the wheat is ready to be harvested.

The panicle length parameter (Table 4) shows that (N 350 3.7.1) g13 has the best panicle length compared to all comparator varieties (9.32 cm). For the parameter number of spikelet, it shows that (N 350 3.7.1) g13 has the highest number of spikelets compared to all comparator varieties (17.56). As for the parameter number of seedlings, genotype (N 350 3.1.3) g3 has the highest number of seeds compared to all comparator varieties (45.17).

Crops that experience stress will experience a decrease in the size of the plant parts produced. This happens because the wheat genotypes that have to stress have relatively fast drying leaves, so the photosynthesis process is not running optimally so that energy and food reserves are not enough available for the growth and development of plant organs. This is in Nur A's opinion (2013) which states that the length of the panicle and the number of spikelets/panicles is determined by the assimilate supply in the vegetative phase as a source of sources for forming panicles in the

generative phase. If the sources are insufficient in the formation of a sink (generative phase), then the structure of spikelets is low.

Table 4. Average Panicle Length, Number of Spikelets per panicle and number of seeds per panicle of several M6 Wheat genotypes.

Genotype	Panicle Length		Number of Spikelets per Panicle		number of seeds per panicle	
(g1) N 350 3.6.2	8,98	abcd	17,33	abcd	41,56	abcd
(g2) N 300 3.6.1	7,97		15,00	c	31,17	d
(g3) N 350 3.1.3	9,01	abcd	17,11	abcd	45,17	abcd
(g4) D 200	8,42	bc	16,56	abcd	36,00	acd
(g5) N 350 3.1.4	7,08		15,83	abcd	34,50	acd
(g6) N 250 2.5.1	8,10		15,17	c	33,83	acd
(g7) M 200 1.7.1	8,25	b	15,89	abcd	41,22	abcd
(g8) N 250 4.6.2	7,38		15,44	c	29,56	
(g9) S 300 8.3.1	7,56		14,00	d	24,00	
(g10) S 6.4.1	8,33	b	15,67	d	41,55	abcd
(g11) S 300 7.9.1	8,22		16,00	abcd	35,00	acd
(g12) S 300 2.1	8,07		8,07	8,07	8,07	
(g13) N 350 3.7.1	9,32	abcd	17,56	abcd	43,44	abcd
(g14) N 200 2.4.B.6	8,02		14,83	c	30,33	
(g15) N 200 2.5.2	8,14		15,50	c	38,67	abcd
(g16) N 200 2.3.3	7,97		15,00	c	33,17	acd
(g17) Dewata (a)	8,09		14,78		27,78	
(g18) Selayar (b)	7,82		14,89		34,22	
(g19) Nias (c)	7,92		13,00		28,33	
(g20) Munal (d)	8,07		14,78		27,67	
NP BNT 5%	0,88		2,03		7,03	

The numbers followed by the same letter in the column (abcd) mean very different from the comparative varieties of Dewa (a), Selayar (b), Nias (c), and Munal (d) at the BNT test level = 0, 05

In Table 5 (Propagation M6) shows that the parameter percentage of empty florets, (N 350 3.7.1) g13 has the least rate of empty florets compared to all comparator varieties, namely (3.33 florists). The weighting parameters of the seed showed that (N 350 3.7.1) g13 had the most substantial weight compared to all comparator varieties (1.79 g). For the mass of 1000 grains, it showed (N 350 3.7.1) g13 had the most substantial weight of 1000 seeds compared to all comparator varieties (42.56 g). As for production, (N 350 3.7.1) g13 has the highest output compared to all comparator varieties, namely (2.74 t.ha-1).

The size of the seeds of wheat plants is influenced by the process of gametogenesis and metabolic processes, the inappropriate agro-climate conditions will affect the operation of gametogenesis of wheat plants, and the amount of assimilates produced after gametogenesis helps the plant in seeds to produce optimal seeds. The same thing started by Acevedo et al., (1991) in Al-Karaki (2012) states that each increase of 1oC from 17oC to 24oC in the seed filling phase can reduce the weight of wheat seeds by about 4%. Less efficient accumulation of assimilates from leaves to seeds is also caused by limited water which is in the process of translocation. The reproduction process starts from microsporogenesis and megasporogenesis, stigma and pollen viability, blooming flowers, pollination, pollen tube growth, early embryonic growth and development, all of which are very susceptible to heat stress. The failure of each of these processes

results in decreased fertilisation or increased embryo abortion, which causes a decrease in the number of seeds, thereby limiting production (Nasaruddin, Farid, Musa, & Iswoyo, 2018).

Table 5. Average Panicle Length, Number of Spikelets per Panicle and Number of Seeds per Panicle of M6 Wheat Genotypes.

Genotype	Persentase Floret Hampa	Bobot Biji Permalai	Bobot 1000 Biji	Produksi
(g1) N 350 3.6.2	7,83 abcd	1,42 abcd	35,44 abcd	2,33 abcd
(g2) N 300 3.6.1	16,67 bd	0,62	23,00	1,83
(g3) N 350 3.1.3	9,78 abcd	1,51 abcd	35,67 abcd	2,26 ab
(g4) D 200	11,11 abcd	1,08 abcd	30,00 a	2,01
(g5) N 350 3.1.4	15,50 abcd	0,72	24,00	1,79
(g6) N 250 2.5.1	13,33 abcd	0,75	25,50	1,82
(g7) M 200 1.7.1	11,00 abcd	1,18 abcd	32,67 ad	2,06
(g8) N 250 4.6.2	15,00 abcd	0,61	27,00	1,98
(g9) S 300 8.3.1	16,33 bd	0,46	23,44	1,75
(g10) S 6.4.1	9,22 abcd	0,98 ad	31,89 ad	2,03
(g11) S 300 7.9.1	8,78 abcd	1,51 abcd	33,00 ad	2,43 abcd
(g12) S 300 2.1	14,17 abcd	0,85	25,39	1,68
(g13) N 350 3.7.1	3,33 abcd	1,79 abcd	42,56 abcd	2,74 abcd
(g14) N 200 2.4.B.6	11,83 abcd	0,80 d	26,17	1,86
(g15) N 200 2.5.2	10,67 abcd	1,06 acd	30,55 ad	2,05
(g16) N 200 2.3.3	12,11 abcd	0,70	22,67	1,78
(g17) Dewata (a)	13,56	0,83	24,33	1,90
(g18) Selayar (b)	22,00	0,92	28,89	1,91
(g19) Nias (c)	14,00	0,83	29,67	1,96
(g20) Munal (d)	17,00	0,61	25,67	2,00
NP BNT 5%	2,22	0,15	4,42	0,33

Table 6. Heritability Values of M6 Wheat mutants.

No	Characters	Heritability	Clasification
1	Number of Stomata	71,00	Height
2	Stomata Density	39,71	medium
3	Chlorophyll Index	99,85	Height
4	Plant height	85,13	Height
5	Number of Tillers	67,43	Height
6	Number of Productive tillers	84,15	Height
7	Flowering day	0,05	Low
8	Harvest Day	2,50	Low
9	Seed filling rate	70,81	Height
10	Length of Panicle	92,93	Height
11	Percentage of Empty Florets	31,55	Medium
12	Number of grain per panicle	82,93	Height
13	Percentage of Empty Florets	94,11	Height
14	Seed Weight per panicle	95,14	Height
15	Weight of 1000 seeds	93,54	Height
16	Yield	85,99	Height

Table 6 shows that almost all characters have high heritability values. The highest heritability was found in the character of the chlorophyll index with heritability (99.85%). The results of the heritability analysis show that in the M6 product, almost all parameters have a high heritability value. This can then be used as an evaluation material for the selection of temperature stress in the lowlands. This is by the opinion of Hadiati, Murdaningsih, Baihaki & Rostini (2003) that for selection, characters with high heritability must be used because these traits will be easily inherited and selection can be made in the early generations. High heritability values indicate that genetic factors play a role more than environmental factors (Alnopri, 2004).

Characters that have high heritability will increase the effectiveness of selection in endurance testing because the observed characteristics are a reflection of the influence of genetic factors compared to environmental impacts. Quantitative characters that have high heritability will result in selection progress for desirable traits, whereas if low heritability is less useful to be used as a selection material (Basir, 2001).

D. Conclusions

1. Genotipe mutan gandum yang memiliki produksi tinggi pada perbanyakan M6 adalah N 350 3.7.1(2,74 t.ha-1), N 350 3.6.2 (2,33 t.ha-1) dan N 350 3.1.3 (2,26 t.ha-1).
2. Karakter yang memiliki nilai heritabilitas tinggi pada M6 Jumlah stomata, Indeks klorofil, tinggi tanaman, jumlah anakan, anakan produktif, laju pengisian biji, panjang malai, jumlah biji permalai, persentase floret hampa, bobot biji permalai, bobot 1000 biji dan produksi.

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