Evaluation of growth and production of wheat lines (*Triticum aestivum* L.) adaptive to lowland

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**Abstract.** Wheat is the world's main food commodity originating from temperate (subtropical) regions. In Indonesia, wheat imports have been increased very high every year. To increase the use of local wheat consumption, especially low gluten needs to be developed. So far, wheat development in Indonesia has been carried out at plateaus > 1000 masl. Development at this height is experiencing competition with horticultural commodities with higher economic value and limited land. The development of wheat in Indonesia in the future is directed at medium-low altitude. This study aims to determine the wheat strain crossbreed of Magic Population adaptive lowland and high production. The study was conducted at the Green House of the Indonesia Cereal Research Institute, Lau Subdistrict, Alleopolea Village, Maros Regency with an average temperature of 25°C in the morning and 32°C in the afternoon. The study took place from October 2017 to February 2018. The study used a Randomized Block Design with 10 lines of Magic Population crosses including MPF 124, MPF 159, MPF 192, MPF 169, MPF 137, MPF 195, MPF 119, MPF 145, MPF 156 and MPF 231 as well as four comparators, namely two national superior varieties (Selayar and Dewata) and two introduction lines (Oasis and HP. 1744) so that there are 14 lines. Each group was repeated 3 times. The results showed that the wheat strains of Magic Population that were adaptive to lowland land with high productivity were MPF 192 (1.80 ton ha⁻¹), MPF 169 (1.66 tons ha⁻¹), MPF 195 (1.54 tons ha⁻¹), MPF 137 (1.44 tons ha⁻¹), MPF 124 (1.42 tons ha⁻¹) and MPF 159 (1.34 tons ha⁻¹). Besides, the result showed that the number of productive tiller, the number of main panicle seeds, and numbers of tiller spike seed could be used as the selection character under lowland.

1. **Introduction**

Wheat (*Triticum aestivum* L.) is a cereal from the family Gramineae (Poaceae) originating from the subtropical region. Wheat is a staple food for most of the world's population. It also plays a role as processed food industrial plant which has a strategic role in meeting the needs of Indonesian people, but the tendency of Indonesian people in consuming processed products derived from wheat causes increased demand for wheat from year to year [1].

The lifestyle of Indonesia society from year to year contributes an impact to the increasing consumption of wheat product, hence the Government takes a step to import wheat. In 2014/2015, Indonesia has reached 7.49 Million tons in importing wheat or on the second ranked in the world after
Egypt 11.06 million tons. Furthermore, Indonesia's wheat imports in 2015/2016 reached 8.10 million tons or ranked second after Egypt's 11.50 million tons. The projection of Indonesia's wheat imports for 2015/2016 has been revised, previously imports in that period were estimated at only 7.8 million tons but due to purchases of wheat for feed from Ukraine up to 300 thousand tons, the project rose to 8.10 million tons. The increase in wheat imports was caused by the increasing consumption of Indonesian wheat from 2012 to 2016 [2]. Wibowo [3] stated the development of wheat cultivation in Indonesia is still very limited. In addition, Farid [4] stated that the limited area of upland area that is widely planted with horticultural commodities that have high economic value also affects the development of wheat in Indonesia, so it is necessary to develop lowland tolerant wheat (<400 m asl).

Sovan [5] stated that to suppress wheat imports, Indonesia needs to make efforts to produce domestic wheat. Hence, it is necessary to do selection on the lines of wheat produced from crossing in order to obtain wheat that is adaptive to temperature based on altitude. One of the criteria for the success of a wheat breeding program in Indonesia is the ability to assemble superior varieties that are adaptive in lowland below 400 m asl. The Obstacle to the development of wheat in the medium-lowlands (<800 m asl) is high temperature stress. Optimal air temperature for the growth and development of wheat is 8-10°C (Subtropical). In Indonesia, such temperatures can only be found in areas with elevations > 1,000 m asl (15 - 24°C), while medium-lowland temperatures range from 25 - 35°C [6].

The effort to increase the productivity of wheat requires genetically high-yielding lines that are supported by genetic and environmental factors. The genes that control these characters are spread in the introductory lines to be tested so that genetic improvement must be through a cross, both single cross and Magic Population. The method of crossing used is as varied as it is Magic Population. It is one of the genetic recombination methods that aims to collect and fix the genes that control the desired traits in one line, so that selection is easier, because of the greater genetic diversity of the resulting population [7]. Based on the description, the study was conducted to evaluate the growth and production of several more wheat lines resulting from crossbreeding of the lowland adaptive Magic Population and high production.

2. Methodology

2.1. Time and Place
The research was conducted at the Screen House of the Cereals Plant Research Institute located in Lau Subdistrict, Allepolea Sub-District, Maros Regency which lasted from October 2017 to February 2018. The average temperature was 25°C in the morning and 32°C in the afternoon.

2.2. Material and Method
The ingredients used in the study were 14 strains of wheat germ, Urea fertilizer, SP36, KCl 60%, Carbofuran 3%, herbicide parakuat diklorida 276 g / l, Insecticide deltamethrin 25g / l, Propineb fungicide 70%, label, rope, plastic picks, envelope paper and sacks. The tools used are digital camera, hoes, bamboo, nails, meters, ruler, markers, plot boards, analytical scales, thermometers, manual scales and other writing stationery.

The study is arranged based on a randomized group design consisting of 10 wheat lines and four checks including two national superior varieties (Selayar and Dewata) and two introduced lines (Oasis and HP. 1744) which were placed randomly. In one test 14 plots were made in which each plot contained 1 line. Data obtained from observations were analyzed using one-way Anova according to a randomized group design (RGD). If it is significantly different, further analysis is done by LSD test (α = 0.05).

The procedures of the research includes land preparation, planting, maintenance, and harvesting. The parameters of observation includes the numbers of productive tillers, number of spikelet, numbers of idle spikelet, numbers of main spike seed, numbers of tiller spike seed and yield. The analysis of variance and biplot analysis used STAR 2.1 program from IRRI Institute.
3. Result

**Table 1.** The average numbers of productive tiller, numbers of spikelet, numbers of idle floret, numbers of main spike seed, number of tiller spike seed, production (ton ha\(^{-1}\)) of wheat lines

| Genotypes | Numbers of Productive Tillers (NPT) | Number of spikelets (NS) | Numbers of idle floret (NIF) | Number of Main spike Seeds (NMSS) | Numbers of tiller spike seed (NTSS) | Yield (ton ha\(^{-1}\)) |
|-----------|-------------------------------------|--------------------------|-----------------------------|-----------------------------------|-------------------------------------|--------------------------|
| g1 (MPF 124) | 2.4                                 | 14,2<sup>cd</sup>         | 26.23<sup>a</sup>            | 16.47<sup>abcd</sup>              | 21.93<sup>abcd</sup>                 | 1.42<sup>ab</sup>            |
| g2 (MPF 159) | 3.4<sup>abcd</sup>                   | 14.3<sup>cd</sup>         | 28.2                         | 16.60<sup>abcd</sup>              | 20.50<sup>abcd</sup>                 | 1.34<sup>cd</sup>            |
| g3 (MPF 192) | 3.5<sup>abcd</sup>                   | 11.6                     | 19.67<sup>abcd</sup>         | 15.13<sup>abcd</sup>              | 25.90<sup>abcd</sup>                 | 1.90<sup>cd</sup>            |
| g4 (MPF 169) | 4.5<sup>abcd</sup>                   | 12.2                     | 18.56<sup>abcd</sup>         | 17.91<sup>abcd</sup>              | 21.24<sup>abcd</sup>                 | 1.66<sup>cd</sup>            |
| g5 (MPF 137) | 2.4                                 | 14.1<sup>cd</sup>         | 26.63<sup>a</sup>            | 15.87<sup>abcd</sup>              | 21.27<sup>abcd</sup>                 | 1.44<sup>cd</sup>            |
| g6 (MPF 195) | 3.3<sup>abcd</sup>                   | 15.6<sup>abcd</sup>       | 29.3                         | 17.60<sup>abcd</sup>              | 22.40<sup>abcd</sup>                 | 1.54<sup>cd</sup>            |
| g7 (MPF 119) | 2.2                                 | 13.3                     | 26.50<sup>a</sup>            | 13.40<sup>abcd</sup>              | 19.60<sup>abcd</sup>                 | 1.17<sup>b</sup>             |
| g8 (MPF 145) | 2.4                                 | 11.7                     | 23.86<sup>abcd</sup>         | 11.33<sup>a</sup>                 | 15.94                                | 0.92                      |
| g9 (MPF 156) | 2.2                                 | 12.8                     | 27.00<sup>a</sup>            | 11.50<sup>abcd</sup>              | 19.83<sup>abcd</sup>                 | 1.18<sup>b</sup>             |
| g10 (MPF 231) | 2.2                                | 13.1                     | 27.83                        | 11.47<sup>abcd</sup>              | 18.73<sup>abcd</sup>                 | 1.04                      |
| g11 (Selayar) | 2.3                                 | 14                      | 30.57                        | 9.93                              | 16.3                                | 1.09                      |
| g12 (Oasis)  | 2.2                                 | 13.3                     | 28.47                        | 11.53                             | 15.87                                | 1.10                      |
| g13 (HP. 1744) | 3.3                                | 12.4                     | 23.7                        | 13.4                              | 18.57                                | 1.14                      |
| g14 (Dewata) | 2                                  | 12.6                     | 27.47                        | 10.43                             | 15.87                                | 1.1                      |
| Average     | 2.7                                 | 13.2                     | 26                            | 13.61                             | 19.55                                | 1.28                      |
| LSD 5%       | 0.56                                | 1.01                      | 3.58                        | 1                                | 1.37                                | 0.1                      |

**Figure 1.** Biplot analysis based on Principal component analysis of the adaptive wheat characters under lowland
4. Discussion

Table 1 on the parameter number of productive tillers showed that g4 genotype has the highest and best average of the four checks. For the highest number of productive tillers with a value (4.5) each was significantly higher from the four comparators genotype g2 (3.4), g3 (3.5) and g6 (3.3) in the parameter the number of productive tillers was higher and significantly different from the comparator Selayar (a) (2.3), Oasis (b) (2.2) and Dewata (d) (2.0). In Indonesia, with warmer temperatures, the average number of productive tillers was 4 stems compared to the number of winter wheat tillers at optimal conditions, only 2-3 stems per crop [8].

Table 1 showed the highest average number of spikelets, namely in genotype g6 (15.6) higher and significantly different from the four checks. The genotypes of g1 (14.2), g2 (14.3) and g5 (14.1) on the number of spikelet parameters were higher and significantly different from HP.1744 (c) (12.4) and Dewata (d) (12), 6). Visually, the long panicle characters are easier and faster to observe than the number of spikelet characters. Therefore, panicle length can be used to characterize the number of spikelet characters [9].

In addition to the number of idle floret, the lowest average number of idle floret is showed in g4 genotype (18.60) and is lower and significantly different from the four checks, g3 genotype (19.67) is lower and significantly different from the four By check, genotype g8 (23.86) was lower and significantly different from comparator Selayar (a) (30.57), Oasis (b) (28.47) and Dewata (d) (27.47), while genotype g1 (26.23), g5 (26.53), g7 (25.60) and g9 (23.00) are lower and significantly different from Selayar (a) (30.57). The number of idle floret is an adverse character because it causes a decrease in yield on wheat. The number of idle floret showed that there is a failure rate of fertilization in wheat plants causing failure to form seeds. The number of idle floret is caused by the flowering phases of many wheat plants which are sterile due to low temperatures and low irradiation of plants. In the highlands is also characterized by low sun intensity so that the plants fail to be fertilized [10].

Furthermore, number of main spike seeds (NMSS) showed that the average number of main panicle seeds was showed in g4 genotype (17.91) and was higher and significantly different from the four checks, while the average number of seedlings of panicle seedlings was indicated in g3 genotype (25.90) and higher and significantly different in the four checks. In the parameters of the number of main panicle seeds that have the best average genotype are g1 (16.47), g2 (14.60), g3 (15.13), g4 (17.91), g5 (15.87) and g6 (17.60) and higher and significantly different from the four comparators. In the parameters of the main panicle seeds, the genotypes g9 (11.50) and g10 (11.47) were higher and significantly different from the comparator Selayar (a) (9.93) and Dewata (d) (10.43), while the g8 genotype (11.33) higher and significantly different from Selayar (a) (9.93). The number of panicle seedlings showed that the best average were genotype g1 (29.93), g2 (20.50), g3 (25.90), g4 (21.24), g5 (21.27) and g6 (22.40) and higher and significantly different from the four checks. In the parameters of the Numbers of tiller spike seed (NTSS) treated g7 (19.60), g9 (19.83) and g10 (18.73) were higher and significantly different from the Selayar (a) check (16.30), Oasis (b) (15.57) and Dewata (d) (15.87).

The number of main panicle seeds and the number of seedling panicles affected the number of spikelet per spike. This is consistent with the research of Ajmal, et al. [11] who reported that the number of main panicle seeds and the number of seedling panicles correlated significantly and positively to the number of spikelets per panicle in the testing of wheat lines. Yield parameters showed that g3 genotype has the highest average yield (1.80 ton ha\(^{-1}\)) and is higher and significantly different from the four checks. The yield parameters showed that the best average is g1 (1.42 tons ha\(^{-1}\)), g2 (1.34 tons ha\(^{-1}\)), g3 (1.80 tons ha\(^{-1}\)), g4 (1.66 ton ha\(^{-1}\)), g5 (1.44 ton ha\(^{-1}\)) and g6 (1.54 ton ha\(^{-1}\)) and higher and significantly different from the four checks. The genotypes of g7 (1.17 tons ha\(^{-1}\)) and g9 (1.18 tons ha\(^{-1}\)) were higher and significantly different from the check of Oasis (b) (1.01 tons ha\(^{-1}\)). The difference in the character of seed weight and production of a plant is strongly influenced by genetic characters. In addition, the gene potential of a plant will be maximized if it is supported by optimal environmental conditions. According to Syafruddin et al. [12], internal factors that stimulate...
plant growth are in genetic control, but climate, soil and biological elements such as pests, diseases and weeds and competition between species and outside species also influence it.

The biplot analysis was a multivariate analysis shown the combination of characters variance vector and the object coordinates in the same dimension. The principal component analysis (PCA) usually used as the source variance in creating the dimension in the biplot analysis [13]. The PCA could compress big data to be the smaller dimension [14]. It was useful, especially to the not equivalent data between the count of parameters and its object. Anshori et al [15] have used the PCA biplot in detecting the specific tolerance index from the not equivalent data. Based on Figure 1, the biplot analysis enough represented to explain the total data because the variance had reached 89.02%. Figure 1 explained that the yield has the same variance direction with the number of the productive tillers, the number of main panicle seeds, and numbers of tiller spike seed. It means that these characters have an opportunity to be the selection characters under lowland so that the optimization of these characters could increase the yield.

5. Conclusions

The result of crosses wheat lines of lowland adaptive Magic Population with high production are g3 (1.80 tons ha\(^{-1}\)), g4 (1.66 tons ha\(^{-1}\)), g6 (1.54 tons ha\(^{-1}\)), g5 (1.44 tons ha\(^{-1}\)), g1 (1.42 tons ha\(^{-1}\)) and g2 (1.34 tons ha\(^{-1}\)). Based on the results of the study it is recommended to do further research to test the consistency of MPF 124, MPF 159, MPF 192, MPF 169, MPF 137 and MPF 195 lines on growth and production in several locations with different environmental conditions. The number of productive tiller, the number of main panicle seeds, and numbers of tiller spike seed could be as the selection character under lowland.

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