Evaluation on growth and production of convergent breeding wheat (*Triticum aestivum* L.) genotypes adaptive to lowland

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Abstract. This study aimed to determine the genotype of wheat from a convergent breeding program that adaptive to lowland and produce high yield, and determine the parameters with high heritability. The study was conducted at the Screen House of Indonesian Cereals Research Institute (ICERI), Maros Regency from October 2017 to February 2018. The study used a Randomized Block Design with 10 wheat genotypes of convergent breeding crossbreeds including CBF 124, CBF 159, CBF 192, CBF 169, CBF 137, CBF 195, CBF 119, CBF 145, CBF 156 and CBF 231 as well as four comparators, namely two national superior varieties (Selayar and Dewata) and two introduced genotypes (Oasis and HP. 1744) resulted in 14 genotypes. The results show that the genotype of wheat from convergent breeding that adaptive to lowland and had high productivity are CBF 192 (1.80 tons ha⁻¹), CBF 169 (1.66 tons ha⁻¹), CBF 195 (1.54 tons ha⁻¹), CBF 137 (1.44 tons ha⁻¹), CBF 124 (1.42 tons ha⁻¹) and CBF159 (1.34 tons ha⁻¹). Characters that have high heritability are plant height, number of tillers and productive tillers, age of flowering and harvest, panicle length, number of spikelet, number of floret, number of grains on the main panicle and on the tillers, weight of grains on the main panicle and on the tillers, and production.

1. Introduction

Wheat (*Triticum aestivum* L.) is a cereal from the family Gramineae (Poaceae) originating from subtropical regions. Wheat is a subtropical native plant as the second carbohydrate producer after rice in the last five years. Wheat is a staple food for most of the world's population [1]. Plants that also play a role as processed food industrial plants have a strategic role in meeting the needs of Indonesian people, but the tendency of Indonesian people to consume processed products derived from wheat causes increased demand for wheat from year to year.

The high demand for wheat in Indonesia continues to be driven by the large needs of the food and animal feed industry that continues to increase in the country. To meet these needs, of course, an increase in wheat production is needed twice the current world wheat production. The current rate of increase in wheat production is still too low to meet future wheat needs [2]. The pattern of life of the Indonesian people from year to year has an impact on increasing consumption of wheat products so the government is taking steps to import wheat. According to Indonesian Flour Producers Association...
(APTINDO), the increase in wheat imports was caused by the increasing consumption of Indonesian wheat from 2012 to 2016 [3]. Increasing wheat import is caused partly from the limited development of the wheat plant in Indonesia [4]. In addition, according to Farid [5], the limited area of highland land which is widely planted with horticultural commodities that have high economic value also affects the development of wheat in Indonesia. Therefore, development of wheat in the lowland ie. <400 m above sea level (asl) is necessary. The availability of land in the highlands in Indonesia is very limited for wheat cultivation on an economical scale, compared to the land available in the lowlands (250 - 400 m asl).

To suppress wheat imports while ensuring the sufficient stock for wheat demand in Indonesia, efforts must be taken to produce domestic wheat [6]. Domestic wheat production needs to be supported by the availability of wheat varieties and the application of cultivation technologies that are in line with agro-climate in Indonesia. For this reason, it is necessary to select the strains 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 develop superior varieties that are adaptive at the locations of <400 m asl. Constraints to the development of wheat in the medium-lowlands (<800 m asl) are the high temperature stress. Optimal air temperature for growth and development of wheat is 8-10 °C (subtropical). In Indonesia, such temperatures can only be found in areas with elevations more than 1,000 m asl (15 – 24 °C), while the medium-lowland temperatures range from 25 – 35 °C [7].

Strain selection and evaluation of genetic diversity provide opportunities for improved character and selection of superior genotypes. To increase wheat productivity, genetically high-yielding varieties/lines are needed, supported by genetic and environmental factors. The genes controlling these characters are spread in the introductory lines to be tested so that genetic improvement must be through crossing, both single cross and convergent breeding. The method of crossing used is as diverse as Convergent Breeding. Convergent breeding is a genetic recombination method that aims to collect and fix genes that control the desired traits in one genotype, so that selection is easier, because of the greater genetic diversity of the resulting population [8]. This approach can also produce new types of superior varieties, varieties that have ideal characteristics. Based on the previous description, one of the efforts to obtain wheat varieties that can grow well in the lowlands is to conduct research on the evaluation of the growth and production of several wheat genotypes resulted from convergent breeding that adaptive to lowland and produce high yield.

2. Methodology

The study was conducted at the Screen House of Indonesian Cereals Research Institute (ICERI), Lau District, Alleopolea Village, Maros Regency with an average temperature of 25 °C in the morning and 32 °C in the afternoon. The trial, carried out from October 2017 to February 2018, used a Randomized Block Design with treatment of 10 wheat crossbreeds genotypes from convergent breeding program including CBF 124, CBF 159, CBF 192, CBF 169, CBF 137, CBF 195, CBF 119, CBF 145, CBF 156 and CBF 231. Four comparator varieties also used consisted of two national superior wheat varieties (Selayar and Dewata) and two introduced genotypes (Oasis and HP. 1744). Therefore there were 14 genotypes and each group was repeated 3 times.

Prior to planting, the field was first sprayed using dichloride 276 g / l herbicide to suppress weed growth in the field followed by soil tillage to obtained good soil structure. The experimental plots, each sized of 1 m x 1 m, were made by using meters and hoes. 3% carbofuran was sprayed on the plots to avoid the attack of ants or wheat-eating insects. Then the seeds were planted with a depth of ± 2 cm. Planting is carried out in an array with 5 rows in each plot and planting spacing between rows of 20 cm. The total seeds planted were 715 seeds per plot.

Wheat plant maintenance included fertilizing, watering, replanting, weeding and controlling pest and disease. The first fertilization was carried out at 10 days after planting (DAP) using 150 kg ha⁻¹ Urea, 200 kg ha⁻¹ SP36, and 100 kg ha⁻¹ KCl. The second fertilization was carried out at 30 DAP using 150 kg ha⁻¹ urea. Disease control was conducted by spraying the insecticide deltamethrin 25g/l on
wheat-infested pests and spraying 70% propineb fungicide on wheat-infested diseases. Pests that attacked the wheat plants were aphids, while diseases that attacked wheat crops were leaf rusts.

Harvesting was conducted depending on the level of maturity of each genotype. Wheat crops can be harvested if characteristics such as leaf color changes from green to dark yellow, panicles droop / fall to the ground and seeds have hardened when pressed by hand. Harvesting was carried out in sunny weather conditions to facilitate the drying process.

Data obtained from observations were analyzed using one-way analysis of variance (ANOVA) according to a randomized block design (RBD). If the treatment showed a significant effect, further analysis was carried out with the Least Significant Difference test ($\alpha=0.05$). Analysis of heritability estimates was conducted based on Stanfield [9].

3. Results

3.1. Plant height, number of tillers and number of productive tillers.

Analysis of variance results show that wheat genotype had a very significant effect on plant height, number of tillers, and number of productive tillers. Table 1 shows that in plant height parameters, there were no genotype treatments showed higher and were significantly different from the Oasis comparative genotype (b) (62.63 cm) except CBF 192 genotype (59.83 cm) and CBF 195 genotype (59.80 cm) which was taller and significantly different from Selayar (a) (55.53 cm). On the parameter of number of tillers, genotype g4 (CBF 169) had the best average of 5.5 tillers and was higher and significantly different from the four comparisons. While the treatments of CBF 124 (4.3 tillers), CBF 159 (4.4 tillers), CBF 192 (4.3 tillers), CBF 137 (4.2 tillers), CBF 195 (4.5 tillers), CBF 145 (4.4 tillers) and CBF 231 (4.2 tillers) were significantly higher and different from the Selayar (a) comparison (3.2 tillers). Observation on the number of productive tillers shows that CBF 169 or the g4 genotype genotypes gave the best and higher average (4.5 tillers) which differed significantly from the four comparisons. The g2 genotype or CBF 159 (3.4 tillers), g3 or CBF 192 (3.5 tillers), and g6 or CBF 195 (3.3 tillers) showed higher average of productive tillers and significantly different from Selayar (a) (2.3 tillers), Oasis (2.2 tillers), and Dewata (d) (2.0 tillers).

| Genotypes | Plant height (cm) | Number of tillers (tillers) | Number of productive tillers (tillers) |
|-----------|------------------|-----------------------------|----------------------------------------|
| g1 (CBF 124) | 57.53           | 4.3<sup>a</sup>              | 2.4                                    |
| g2 (CBF 159) | 56.73           | 4.4<sup>a</sup>              | 3.4<sup>abcd</sup>                      |
| g3 (CBF 192) | 59.83<sup>a</sup> | 4.3<sup>a</sup>              | 3.5<sup>abcd</sup>                      |
| g4 (CBF 169) | 53.87           | 5.5<sup>abcd</sup>           | 4.5<sup>abcd</sup>                      |
| g5 (CBF 137) | 56.57           | 4.2<sup>a</sup>              | 2.4                                    |
| g6 (CBF 195) | 59.80<sup>a</sup> | 4.5<sup>a</sup>              | 3.3<sup>abcd</sup>                      |
| g7 (CBF 119) | 53.47           | 3.9                          | 2.2                                    |
| g8 (CBF 145) | 53.77           | 4.4<sup>a</sup>              | 2.4                                    |
| g9 (CBF 156) | 52.67           | 3.9                          | 2.2                                    |
| g10 (CBF 231)| 53.57           | 4.2<sup>a</sup>              | 2.2                                    |
| g11 (Selayar) (a) | 55.53       | 3.2                          | 2.3                                    |
| g12 (Oasis) (b) | 62.63          | 4.2                          | 2.2                                    |
| g13 (HP. 1744) (c) | 61.57      | 4.3                          | 3.3                                    |
| g14 (Dewata) (d) | 60.37          | 3.9                          | 2.0                                    |
| Mean       | 56.99           | 4.2                          | 2.7                                    |
| LSD<sub>0.05</sub> | 2.63           | 0.68                         | 0.56                                   |

The numbers followed by the same letters (a, b, c, d) mean significantly different from the Selayar (a), Oasis (b), HP.1744 (c) and Dewata (d) varieties in the LSD test $\alpha = 0.05$. 

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3.2. Flowering age, harvest age, and seed filling period.
Analysis of variance show that genotype had a very significant effect on flowering age, age of harvest, and seed filling period. The results of the LSD test (α=0.05) in Table 2 shows that in the age of flowering and harvest parameters no genotypes found to initiate flower earlier than the four comparison genotypes. On the other hand, in the seed filling period parameter, it shows that the treatment of g10 or CBF 231 genotype resulted in the shortest time (32 days), and was significantly different from the comparison genotypes of Selayar (a) (36 days), HP 1744 (c) (39 days), and Dewata (d) (41 days). The treatments of g1 or CBF 124 genotype (36 days), g2 or CBF 159 genotype (36 days), g3 or CBF 192 (35 days), g4 or CBF 169 (33 days), and g7 or CBF 119 (35 days) showed shorter period in seed filling and significantly different from the comparison genotypes of HP. 1744 (c) (39 days) and the Dewata (d) (41 days).

Table 2. Average flowering age (DAP), harvest age (DAP), and seed filling period (days) of various wheat genotypes from convergent breeding adaptive to lowland

| Genotypes | Flowering age (DAP) | Harvest age (DAP) | Seed filling period (days) |
|-----------|---------------------|-------------------|---------------------------|
| g1 CBF 124 | 64                  | 100               | 36<sup>cd</sup>           |
| g2 CBF 159 | 67                  | 103               | 36<sup>cd</sup>           |
| g3 CBF 192 | 68                  | 103               | 35<sup>cd</sup>           |
| g4 CBF 169 | 63                  | 97                | 33<sup>cd</sup>           |
| g5 CBF 137 | 58                  | 97                | 39                        |
| g6 CBF 195 | 58                  | 97                | 38                        |
| g7 CBF 119 | 62                  | 97                | 35<sup>cd</sup>           |
| g8 CBF 145 | 56                  | 95                | 39                        |
| g9 CBF 156 | 58                  | 98                | 40                        |
| g10 CBF 231| 66                  | 98                | 32<sup>bcd</sup>         |
| g11 Selayar (a) | 42 | 78 | 36 |
| g12 Oasis (b) | 44 | 78 | 34 |
| g13 HP. 1744 (c) | 42 | 81 | 39 |
| g14 Dewata (d) | 42 | 83 | 41 |
| Mean | 57 | 93 | 3.7 |
| LSD<sub>0.05</sub> | 2.49 | 3.61 | 3.28 |

The numbers followed by the same letters (a, b, c, d) mean significantly different from the Selayar (a), Oasis (b), HP. 1744 (c) and Dewata (d) varieties in the LSD test α = 0.05. DAP = days after planting.

3.3. Length of panicle and number of spikelet.
Analysis of variance show that wheat genotype had a very significant effect on panicle length and number of spikelets parameters. The results of the LSD test (α=0.05) in Table 3 shows that the genotypes g4 or CBF 169 (8.0 cm) and g6 or CBF 195 (8.4 cm) had the longest panicle average and were significantly different from the four comparison genotypes. Whereas the length of panicle of g1 or genotype CBF 124 (7.4 cm) and g2 or genotype CBF 159 (7.4 cm) were higher and significantly different from Selayar (a) (6.7 cm), whereas the g3 or genotype CBF 192 (7.5 cm) treatment had significantly longer panicle than Selayar (a) (6.7 cm) and HP. 1744 (c) (6.9 cm) comparison genotypes. For parameter the number of spikelet, genotype g6 or CBF 195 had the best average (15.6 spikelet) and was significantly higher than the four comparison genotypes. Treatments of g1, g2, and g5 or genotypes CNF 124, CBF 159, and CBF 137 showed higher number of spikelet of 14.2, 14.3, and 14.1 spikelet, respectively compared to HP. 1744 (c) (12.4 spikelet) and Dewata (d) (12.6) spikelet) comparison genotypes.
Table 3. Average length of panicle (cm) and number of spikelet (spikelet) of various wheat genotypes from convergent breeding adaptive to lowland

| Genotypes  | Length of panicle (cm) | Number of spikelet (spikelet) |
|------------|------------------------|------------------------------|
| g1 (CBF 124) | 7.4<sup>a</sup>          | 14.2<sup>cd</sup>             |
| g2 (CBF 159) | 7.4<sup>a</sup>          | 14.3<sup>cd</sup>             |
| g3 (CBF 192) | 7.5<sup>sc</sup>         | 11.6                         |
| g4 (CBF 169) | 8.0<sup>abcd</sup>       | 12.2                         |
| g5 (CBF 137) | 7.1                    | 14.1<sup>cd</sup>             |
| g6 (CBF 195) | 8.4<sup>abcd</sup>       | 15.6<sup>abcd</sup>           |
| g7 (CBF 119) | 6.9                    | 13.3                         |
| g8 (CBF 145) | 6.2                    | 11.7                         |
| g9 (CBF 156) | 6.7                    | 12.8                         |
| g10 (CBF 231)| 6.9                    | 13.1                         |
| g11 (Selayar) | 6.7               | 14.0                         |
| g12 (Oasis) | 7.0                  | 13.3                         |
| g13 (HP. 1744) | 6.9           | 12.4                         |
| g14 (Dewata) | 7.3                  | 12.6                         |
| Mean        | 7.2                  | 13.2                         |
| LSD<sub>0.05</sub> | 0.50                | 1.01                        |

The numbers followed by the same letters (a, b, c, d) mean significantly different from the Selayar (a), Oasis (b), HP.1744 (c) and Dewata (d) varieties in the LSD test α = 0.05.

Table 4. Average number of grain on the main and tiller’s spikelet (grains) of various wheat genotypes from convergent breeding adaptive to lowland

| Genotypes  | Number of grain on main panicle (grains) | Number of grain on tiller panicle (grains) |
|------------|------------------------------------------|-------------------------------------------|
| g1 (CBF 124) | 16.47<sup>abcd</sup>                     | 21.93<sup>abcd</sup>                      |
| g2 (CBF 159) | 14.60<sup>abcd</sup>                     | 20.50<sup>abcd</sup>                      |
| g3 (CBF 192) | 15.13<sup>abcd</sup>                     | 25.90<sup>abcd</sup>                      |
| g4 (CBF 169) | 17.91<sup>abcd</sup>                     | 21.24<sup>abcd</sup>                      |
| g5 (CBF 137) | 15.87<sup>abcd</sup>                     | 21.27<sup>abcd</sup>                      |
| g6 (CBF 195) | 17.60<sup>abcd</sup>                     | 22.40<sup>abcd</sup>                      |
| g7 (CBF 119) | 13.40<sup>abcd</sup>                     | 19.60<sup>abcd</sup>                      |
| g8 (CBF 145) | 11.33<sup>a</sup>                       | 15.94                                     |
| g9 (CBF 156) | 11.50<sup>ad</sup>                      | 19.83<sup>abcd</sup>                      |
| g10 (CBF 231)| 11.47<sup>ad</sup>                      | 18.73<sup>abcd</sup>                      |
| g11 (Selayar) | 9.93                             | 16.30                                     |
| g12 (Oasis) | 11.53                              | 15.57                                     |
| g13 (HP. 1744) | 13.40         | 18.57                                     |
| g14 (Dewata) | 10.43                              | 15.87                                     |
| Mean        | 13.61                              | 19.55                                     |
| LSD<sub>0.05</sub> | 1.00                        | 1.37                                      |

The numbers followed by the same letters (a, b, c, d) mean significantly different from the Selayar (a), Oasis (b), HP.1744 (c) and Dewata (d) varieties in the LSD test α = 0.05.
3.4. Number of grain on the main and tiller’s panicle.
The results of variance analysis show that wheat genotype had a very significant effect on the number of grain on main panicle and the number of grain on the tiller panicles. Table 4 shows better average values for parameter the number of grain on the main panicle were shown by treatments g1, g2, g3, g4, g5, and g6 or genotype CBF 124, CBF 159, CBF 192, CBF 169, CBF 137, and CBF 195. These figure were significantly higher than the four comparisons. The number of grain on the main panicle in treatment g9 or genotype CBF 156 and g10 or genotype CBF 231 resulted in significantly higher values than the comparator genotypes of Selayar and Dewata. Whereas g8 treatment or CBF 145 was higher and significantly different from Selayar. Similarly, in the parameter of the number of panicle on tiller panicle, treatment g1, g2, g3, g4, g5, and g6 or genotype CBF 124, CBF 159, CBF 192, CBF 169, CBF 137, and CBF 195 were significantly higher than the average values shown by four comparisons. Treatment g7 or genotype CBF 119, g9 or genotype CBF 156, and g10 or genotype CBF 231 showed higher number of grain on the tiller panicle and significantly different from the comparator genotypes of Selayar, Oasis, and Dewata.

Table 5. Average weight of grain on the main and tiller panicle (g) of various wheat genotypes from convergent breeding adaptive to lowland

| Genotypes   | Weight of grain on the main panicle (g) | Weight of grain on the tiller panicle (g) |
|-------------|-----------------------------------------|------------------------------------------|
| g1 (CBF 124)| 0.68abcd                                 | 0.90abcd                                 |
| g2 (CBF 159)| 0.62abcd                                 | 0.87abcd                                 |
| g3 (CBF 192)| 0.74abcd                                 | 1.26abcd                                 |
| g4 (CBF 169)| 0.84abcd                                 | 1.00abcd                                 |
| g5 (CBF 137)| 0.68abcd                                 | 0.92abcd                                 |
| g6 (CBF 195)| 0.75abcd                                 | 0.96abcd                                 |
| g7 (CBF 119)| 0.53a                                    | 0.77b                                    |
| g8 (CBF 145)| 0.43                                     | 0.60                                     |
| g9 (CBF 156)| 0.48                                     | 0.83bcd                                  |
| g10(CBF 231)| 0.44                                     | 0.72                                     |
| g11(Selayar) | 0.46                                     | 0.75                                     |
| g12(Oasis)  | 0.48                                     | 0.64                                     |
| g13(HP. 1744)| 0.53                                     | 0.73                                     |
| g14(Dewata) | 0.49                                     | 0.74                                     |
| Mean        | 0.58                                     | 0.84                                     |
| LSD 0.05    | 0.05                                     | 0.09                                     |

The numbers followed by the same letters (a, b, c, d) mean significantly different from the Selayar (a), Oasis (b), HP.1744 (c) and Dewata (d) varieties in the LSD test $\alpha = 0.05$.

3.5. Weight of grain on the main and tiller’s panicle
The variance analysis results show that wheat genotype had very significant effect on the weight of grain on the main and tillers panicle. Table 5 shows that the main panicle seed weight parameters that have average values that significantly higher than the four comparison genotypes were treatment g1 (0.68 g), g2 (0.62 g), g3 (0.74 g), g4 (0.84 g), g5 (0.75 g) and g6 (0.75 g) or genotypes CBF 124, CBF 159, CBF 192, CBF 169, CBF 137, and CBF 195. The treatment g7 or genotype CBF 119 showed average value that was higher and significantly different from the Selayar. The parameter of the weight of grain on the tillers panicle showed by treatment g1 (0.90 g), g2 (0.87 g), g3 (1.26 g), g4 (1.00 g), g5 (0.92 g) and g6 (0.96 g) or genotypes CBF 124, CBF 159, CBF 192, CBF 169, CBF 137, and CBF 195 were significantly higher from the four comparison genotypes. The treatment g7 or CBF
119 (0.77 g) had average weight of grain that was higher and significantly different from the Oasis comparator (b) (0.64 g), while the treatment g9 or CBF 156 (0.83 g) was higher and significantly different from the comparator Oasis (b) (0.64 g), HP. 1744 (c) (0.73 g) and Dewata (d) (0.74 g).

3.6. Weight of 100 grain and productivity

The variance analysis show that wheat genotypes had a very significant effect on the weight of 100 seeds and productivity parameters. Table 6 shows that the genotypes with higher weight of 100 grain were treatment g3 (CBF 192) and g4 (CBF 169) indicated by average values of 4.88 g and 4.71 g, respectively, and were significantly different from Oasis comparator (b) (4.1 g) and HP. 1744 (c) (3.95 g). The treatment of g5 or genotype CBF 137 showed significantly higher weight of 100 grain than the HP.1744 (c) (3.95 g) comparison. For production parameter, genotypes that showed higher average values were 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) or genotypes CBF 124, CBF 159, CBF 192, CBF 169, CBF 137, and CBF 195, respectively. These productivity were significantly different from the productivity of the four comparisons. The treatments of g7 or CBF 119 (1.17 tons ha⁻¹) and g9 or CBF 156 (1.18 tons ha⁻¹) showed higher average values on the production parameters and significantly different from the comparison of Oasis (b) (1.01 tons ha⁻¹).

Table 6. Average weight of 100 grain (g) and productivity (ton ha⁻¹) of various wheat genotypes from convergent breeding adaptive to lowland.

| Genotypes     | Weight of 100 grains (g) | Production (ton ha⁻¹) |
|---------------|--------------------------|-----------------------|
| g1 (CBF 124)  | 4.10                     | 1.42abc               |
| g2 (CBF 159)  | 4.24                     | 1.34abc               |
| g3 (CBF 192)  | 4.88bc                   | 1.80bcd               |
| g4 (CBF 169)  | 4.71bc                   | 1.66bcd               |
| g5 (CBF 137)  | 4.31c                    | 1.44bcd               |
| g6 (CBF 195)  | 4.29                     | 1.54abcd              |
| g7 (CBF 119)  | 3.95                     | 1.17b                 |
| g8 (CBF 145)  | 3.76                     | 0.92                  |
| g9 (CBF 156)  | 4.20                     | 1.18b                 |
| g10 (CBF 231) | 3.84                     | 1.04                  |
| g11 (Selayar) | (a)                      | 4.60                  | 1.09                  |
| g12 (Oasis)   | (b)                      | 4.13                  | 1.01                  |
| g13 (HP. 1744)| (c)                      | 3.95                  | 1.14                  |
| g14 (Dewata)  | (d)                      | 4.67                  | 1.10                  |
| Mean          |                          | 4.26                  | 1.28                  |
| LSD 0.05      |                          | 0.35                  | 0.10                  |

The numbers followed by the same letters (a, b, c, d) mean significantly different from the Selayar (a), Oasis (b), HP.1744 (c) and Dewata (d) varieties in the LSD test α = 0.05.

3.7. Heritability values

Table 7 shows all the observed characters, both vegetative, generative to production components, which have varying heritability values, based on the index value of each character. Heritability values obtained from 0.49 to 0.95. Based on the results of the heritability analysis in Table 7, almost all parameters have a high heritability value except for the parameters of the seed filling period and weight of 100 grains that showed moderate heritability.
Table 7. Heritability values of wheat genotypes from convergent breeding adaptive to lowland

| Character                        | \( h^2 \) value | Category   |
|----------------------------------|-----------------|------------|
| Plant height                     | 0.80            | High       |
| Number of tillers                | 0.52            | High       |
| Number of productive tillers     | 0.81            | High       |
| Length of panicle                | 0.75            | High       |
| Number of spikelet               | 0.58            | High       |
| Flowering age                    | 0.95            | High       |
| Harvest age                      | 0.89            | High       |
| Seed filling period              | 0.38            | Moderate   |
| Number of grain on the main panicle | 0.90        | High       |
| Number of grain on the tiller’s panicle | 0.86        | High       |
| Weight of grain on the main panicle | 0.87         | High       |
| Weight of grain on the tiller’s panicle | 0.84        | High       |
| Weight of 100 grain              | 0.50            | Moderate   |
| Productivity                     | 0.89            | High       |

\( 0 < h^2 \leq 0.20 \) (low), \( 0.21 < h^2 \leq 0.50 \) (moderate), \( h^2 \geq 0.50 \) (high).

4. Discussion

Environmental variations during the study had an average morning temperature of 25 \( ^\circ \)C and an average daytime temperature of 32 \( ^\circ \)C. One of the constraints faced in this study was environmental factors including temperature and high irradiation intensity, where wheat crops are plants that are very sensitive to these environmental factors.

Results of analysis of variance show that genotype treatment had a very significant effect on almost all observational characters. This shows that the selected genotypes have quite wide diversity and can produce the best genotype from several genotypes tested. Although the results of the analysis of plant height showed that the comparison genotype of Oasis was the tallest among all genotypes (62.63 cm) and was higher and significantly different in all treatments, the tested genotype from the convergent breeding that had the best average of plant height was g3 (59.83 cm) and the g6 (59.80 cm). The plant height of these genotypes was higher and significantly different from the Selayar (a) comparison (55.53 cm). Increased plant height in wheat (plant height growth) occurs due to cell division activity that results in the increased number of cells. This process is inseparable from the physiological activities in the plant body. The average plant height indicates that the results of convergent breeding are included in the short wheat range category. This is in accordance with the opinion of Budiarti [10] who grouped wheat plants into categories based on the plant height namely short (53.5 - 65.2 cm), moderate (65.2 -76.9 cm), and tall (> 76.9 cm).

The results of the variance in the number of tillers and the number of productive tillers showed that g4 treatment had the highest and best average number of tillers compared to the four comparison genotypes. In Indonesia with warmer temperatures the average number of productive tillers is 4 stems compared to the number of productive tillers of winter wheat at optimal conditions of only 2-3 stems per crop [11]. In the flowering age parameter, it was found that none of the treatments had an earlier average flowering age than the four comparisons. The average age of fastest flowering is shown in the Selayar, HP.1744 and Dewata comparisons, which is 42 DAP and is significantly different in all treatments. The difference in flowering age is due to the adjustment of the flowering time of wheat plants and also the adjustment of the physiological conditions of each plant to the environment. This is consistent with the opinion of Glover [12] which stated that the flowering behaviour and flowering of plants are closely related to the physiological conditions of plants and the influence of environmental
factors which specifically include the influence of the intensity and duration of irradiation, the effect of temperature, and water availability on the plant growth environment.

Similarly to flowering age, harvest age parameter indicates that no treatment has an average faster and better harvest age than the four comparisons. The fastest average harvest age is shown by the Selayar and Dewata comparator genotypes, which was 78 DAP and is higher and significantly different in all treatments. Harvesting is done in stages that in accordance with crop conditions. Harvesting is done in stages with the aim to prevent the seeds from germinating in the spikelet, where the appearance of panicles appears and the stems of the plant begin to turn yellow. Harvesting can be done after visible characteristics such as changing the color of the leaves from green to dark yellow, panicles have ducked or drooped to the ground and the seeds have hardened [13]. Period of seed filling parameter of the tested genotype showed that the fastest and best seed filling rates were shown in g10, g1, g2, g3, g4, and g7. This value is lower and significantly different from HP.1744 and Dewata. The assimilation of photosynthesis becomes a limiting factor under high temperature pressure in the tropics compared to temperate climates, especially because high temperature stress increases during the process of seed filling, and at the same time, the need for faster assimilation results [2].

The panicle length and number of spikelet parameters showed that the average length of panicle and number of spikelets indicated by genotype were higher and significantly different from the four comparisons. 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 character selection [14]. The highest number of grain on the main panicle and on the tillers panicle were shown by genotypes g4 and g3, respectively. These parameter values were higher and significantly different from the four comparisons. This is in accordance with the research of Ajmal et al. [15] who reported that the number of grain on the main and on the tillers' panicle correlated significantly and positively to the number of spikelet per panicle in the testing of wheat lines.

The average grain weight in main panicles and tillers panicles show that the higher seed weight was shown by g4 and g3 which were significantly different in the four comparisons. This shows that g3 and g4 seeds have a size large enough to affect the weight of the seeds. Data from the production variance shows that the g3 treatment had the highest average production which was significantly higher than the four comparisons. 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 Taiz and Zeiger [16], internal factors stimulating 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.

Heritability is a quantitative benchmark to determine whether the differences in the phenotype of a character caused by genetic or environmental factors, so that it can give an idea whether the characters observed are more influenced by genetic or environmental factors. Almost all morphological characters in the vegetative and generative phases have high heritability except for the period of seed filling and the weight of 100 grains which has a moderate heritability. The dominant genetic factor is preferred in the process of plant selection to create new superior varieties because there is a higher chance of the descendants in inheriting the parent characters. Therefore, the selection will be effective if the population has a high estimated heritability value. According to Aryana [17] the estimated high heritability value shown by certain characters in an environment indicates an opportunity for genetic improvement of these traits using the method of mass selection or pure strain selection.

5. Conclusions
1. The genotype of wheat from convergent breeding adaptive to lowland with high production are CBF 192 (1.80 tons ha⁻¹), CBF 169 (1.66 tons ha⁻¹), CBF 195 (1.54 tons ha⁻¹), CBF 137 (1.44 tons ha⁻¹), CBF 124 (1.42 tons ha⁻¹), and CBF 159 (1.34 tons ha⁻¹).
2. Characters that have high heritability are plant height, number of tillers, number of productive tillers, flowering age, harvest age, panicle length, number of spikelet, number of grain on the
main panicle seeds, number of grain on the tillers panicle, weight of grain on the main panicle, weight of grain on the tillers panicle, and production.

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