**YIELD AND AGRONOMIC PERFORMANCE OF LATE MATURING FOOD BARLEY VARIETIES IN SIDAMA AND GEDEO HIGHLANDS OF SOUTHERN ETHIOPIA**

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**ABSTRACT**

Barley (Hordeum vulgare L.) is one of the five major cereal crops grown in Ethiopia. Fourteen late maturing food barley varieties and the local check were laid out in RCBD with three replications at three Research Sub Centers, at Bule in 2013 and 2014 whereas at Gedeb and Abera Gelede in 2014 only. The objective of this study was to select, and recommend the best adapted and high yielding late maturing food barley varieties for Sidama and Gedeo Zones of Sothern Ethiopia. Mean grain yield across locations indicated that six varieties were significantly out yielded the local check viz variety HB 1307,Cross 41/98, HB 42, EH 1493, Dimtu, and Ardu 1260B which gave 6273.1, 5690.8, 5540.6, 5181, 5067.9, 5047.3 kg ha-1 respectively. These high yielding varieties gave a yield advantage of 39.07, 26.16, 22.92, 14.86, 12.35, and 11.90 percent respectively compared to the local check. Therefore those high yielding varieties and wide adaptable across locations would be popularized and scaled up for production in the tested areas and similar agro-ecologies of Southern Ethiopia highlands. For specific adaptation variety, Abdane, was one of the high yielding varieties at Bule areas and varieties Shedeho, Agegnehu and, Yedogit were adapted to Abera Gelede highlands but none of these varieties was high yielding across locations and can be recommended for production in their niche where they are best-suited areas. Promotions of recently released barley varieties are important for barley growing farmers to easily access them and to increase production and productivity of farmers.

Keywords: Adaptability, Barley varieties, Hordeum vulgare, Yield component

**INTRODUCTION**

Barley (Hordeum vulgare L.) is one of the five major cereal crops grown in Ethiopia highlands for thousands of years (Derbew, 2020). It is the fifth most important crop after tef, maize, sorghum, and wheat both in area coverage and total production (CSA, 2020). Barley has a wide range of adaptation and can be grown in altitude over 3,400 m.a.s.l. on steep slopes, degraded soils, and in stressed areas with occasionally drought and frost where other cereals fails to grow ( Bekele et al., 2005; Mulatu and Lakew 2011). In such areas, barley is the only source of food, homemade drinks, animal feed, and cash. In Ethiopia, barley is generally grown in two different planting seasons per year: during the long rainy season (*Meher*) and the short rainy season (*Belg*) (Tanto et al., 2009). Barley is a dependable source of food in the highlands as is produced during the main and short rainy seasons as well as under residual moisture (Tilahun et al., 2015). The late-barley production system is the dominant in the highland areas of Ethiopia and is practiced during *Meher*, or the main rainy season (June to October) (Bekele et al., 2005). More than 47 food barley varieties have been released nationally (Crop Variety Register 2021). Despite releasing many varieties extension work on the promotion of improved varieties in the country has been very poor compared with that of bread wheat and maize (Mulatu and Lakew, 2011). Barley productivity is limited by poor soil fertility, frost, water logging, insect and leaf diseases, moisture stress, and low yielding varieties and in adequate agronomic practices (Tilahun et al., 2015). These produce poor yields and have been practiced for centuries. Despite releasing many barley varieties in the country few have been accessed by farmers with their agronomic practices, this is accompanied by low productivity. For this study 14 late-maturing varieties were collected from Holetta Agricultural Research Center, and the local checks collected from the farmer’s stock around the experimental sites were evaluated in the main rainy season (July to January). One hundred farmers from five villages 20 from each village visited the experiments during the physiological maturity period. Those farmers were appreciated especially for late maturing varieties than other experiments of early maturing and malt barley varieties in the sub-center. The objective of this study was to select, and recommend the best adapted and high yielding late maturing food barley varieties for Sidama and Gedeo Zones of Southern Ethiopia.

**MATERIALS AND METHODS**

**Description of the experimental area**

The study was conducted for two years (2013 to 2014) at Bule Agricultural Research Sub Center (06018'02.5''N, 38024’18.2''E, Elevation 2842 meters above sea level (Essayas and Ali, 2006) and one year (2014) at Abera Gelede (06041.5''N, 380704E, elevation 2697 m.a.s.l.) and at Gedeb (06057'41.5''N, 38015'35.56''E) in main cropping season (July to January). Bule and Gedeb are in Gedeo Zones and Abera Gelede is the then Sidama Zone (Now Sidama Regional State).

**Treatments, experimental design and cultural practices**

Fourteen late maturing food barley varieties and, the local check (Table 1) were tested for two years in 2013 and 2014 using Randomized Complete Block Design (RCBD) with three replications. The experiment was sown at a seed rate of 100 kg ha-1 during the main cropping season (July to January) at Bule, Abera Gelede, and Gedeb Sub Centers. Each plot was made up of six rows of 2.5 m length. The spacing between rows was 20 cm apart. The adjacent plots were separated by a blank row in both years. Nitrogen and phosphorus fertilizers were applied at the rate of 41 N and 46 P2O5 at planting, using urea and DAP as a source of N and P2O5. One -third of the total amount of nitrogen was applied at planting in the form of urea and 2/3 after the first weeding. But the whole DAP was applied at planting as a source of phosphorus and nitrogen. Broad leaf weeds were controlled using 2;4-D herbicide applied four weeks after planting at the rate of one liter per 200 liters of water ha-1 followed by two hand weeding with an interval of 15 days after herbicide application.

Table 1. Description of plant materials

|  |  |  |  |
| --- | --- | --- | --- |
| Variety | Year of release | Productivity quintal ha-1 | Altitude meter above sea level |
| HB 1307 | 2006 | 35-50 | 2000-3000 |
| Shege | 1985 | 23-51 | 2300-2800 |
| HB 42 | 1984 | 32-55 | 2000-2800 |
| Ardu 1260B | 1986 | 36-50 | 2200-2800 |
| Dimtu | 2001 | 20-40 | 2300-2800 |
| Cross 41/98 | 2012 | 25-56 | 2000-2600 |
| EH 1493 | 2012 | 25-61 | 2300-2800 |
| Yedogit | 2005 | 23.5 | 2600-3000 |
| Estayish | 2004 | 19.6 | 2600-3000 |
| Tiret | 2004 | 23 | 2600-3000 |
| Shedeho | 2003 | 15-26 | 2600-2900 |
| Harbu | 2004 | 15.5-44.9 | 2300-2600 |
| Agegnehu | 2007 | 29 | 2600-3000 |
| Abdane | 2011 | 15-32 | 2300-2600 |
| Local check |  |  |  |

One quintal= 100 kg

Source: Crop Variety Registry from 1984 to 2012

**Data collection and data analysis**

Days to heading and maturity, grain filling period, plant height (cm), spike length (cm), spikelet per spike, 1000 kernel weight (g), and grain yield were collected from the four central rows. Days to heading were recorded as when the spikes of 50% of the culm in a plot had fully extruded out. Physiological maturity was recorded when the plants had almost lost their green color from both vegetative and reproductive tissues. Plant height was measured from the ground level to the tip of the spike excluding the owns after physiological maturity. Grain yield was estimated after adjusting 12.5% seed moisture content. Analysis of variance (ANOVA) was conducted using SAS (2002) and mean separation was done using Duncan Multiple Test Range Test (DMRT).

**RESULTS**

Combined analysis of variance showed that there was a significant difference (P<0.0001) for all agronomic, yield and yield component traits (Table 2). On the other hand, the ANOVA exhibited the presence of significant interaction of location by treatment for all agronomic, yield, and yield component traits.

Table2. Combined analysis of variance for late maturing food barley varieties

|  |  |  |
| --- | --- | --- |
| Source of variation | DF | Mean square |
| Days to heading | Days to maturity | Grain filling period | Plant height (cm) | Spike length (cm) | Spikelet per spike | 1000 kernel weight (g) | Grain yield (kg ha-1) |
| Loc | 3 | 2600.69\*\*\* | 7245.45\*\*\* | 10093.63\*\*\* | 1710.74\*\*\* | 18.28\*\*\* | 231.69\*\*\* | 2256.91\*\*\* | 119110846.0\*\*\* |
| Rep(Loc) | 8 | 8.66ns | 5.76ns | 3.06ns | 7.77ns | 0.19ns | 0.28ns | 20.81\*\* | 966069.0\*\* |
| Trt  | 14 | 393.20\*\*\* | 452.66\*\*\* | 53.47\*\*\* | 447.09\*\*\* | 1.06\*\*\* | 18.92\*\*\* | 67.23\*\*\* | 3972262.4\*\*\* |
| Loc\*Trt | 42 | 59.89\*\*\* | 57.81\*\*\* | 57.64\*\*\* | 66.20\*\*\* | 1.47\*\*\* | 10.22\*\*\* | 28.04\*\*\* | 967425.2\*\*\* |

DF= Degree of freedom

**Agronomic characters**

Barley varieties have differed for days to heading, maturity, grain-filling period, and plant height ranging from 70 to 88 days, 57 to 65 days, and 95.8 to 118.6 cm for days to heading, maturity, grain-filling period, and plant height respectively (Table 3).Varieties Ardu 1260B, HB 42 and the local check took longer days to head 88,87, and 87 days respectively, while variety Harbu was earlier to head (70 days) (Table 3). Variety Ardu 1260B took longer days to reach physiological maturity (148 days). But regarding grain filling period variety, HB1307 had a longer grain filling period (65 days). Variety Ardu 1260B was the tallest (118.6 cm) of all the rest of varieties including the check.

Table3. Combined mean performance of agronomic, yield and yield component traits of late maturing food barley varieties across locations in Southern Ethiopia.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variety  | DH | DM | GFP | PH | SL | SPS | TKW | GY | YA |
| HB 1307 | 82b | 147ab | 65a | 103.0d-f | 7.0a-c | 20.6b | 47.9ab | 6273.1a | 39.07 |
| Shege | 84b | 142e | 58b-e | 103.2d-f | 6.9a-c | 19.9cd | 48.8a | 4222.8g | -6.38 |
| HB 42 | 87a | 146b | 58b-e | 103.0d-f | 6.6c-e | 19.6de | 47.3a-c | 5544.6bc | 22.92 |
| Ardu 1260B | 88a | 148a | 60b-d | 118.6a | 7.0a-c | 19.4e | 47.0a-d | 5047.3de | 11.90 |
| Dimtu | 83b | 143cc-e | 59b-e | 114.2b | 7.3a | 21.3a | 46.2b-f | 5067.9de | 12.35 |
| Cross 41/98 | 82b | 139f | 57de | 103.9de | 7.2ab | 20.3bc | 45.2d-g | 5690.8b | 26.16 |
| EH 1493 | 84b | 145bc | 61b | 101.0gh | 7.1ab | 20.2bc | 44.7e-g | 5181.1cd | 14.86 |
| Yedogit | 83b | 142de | 59b-e | 109.9c | 6.7b-d | 18.2g | 45.5c-g | 4832.3d-f | 7.13 |
| Estayish | 75cd | 132hi | 56e | 97.8j | 6.2e | 17.6h | 44.5fg | 4387.6fg | -2.73 |
| Tiret | 77c | 135g | 58c-e | 101.8g-h | 7.0a-c | 17.4h | 42.5hi | 4630.6e-g | 2.66 |
| Shedeho | 77c | 134gh | 56e | 100.2hi | 6.4de | 18.7f | 41.5ij | 4631.0e-g | 2.67 |
| Harbu | 70e | 130i | 61b-d | 104.6d | 6.5c-e | 17.5h | 43.9gh | 4300.4g | -4.66 |
| Agegnehu | 73d | 134gh | 61b | 98.6ij | 6.6c-e | 17.6h | 46.7b-e | 4709.6d-g | 4.41 |
| Abdane | 73d | 133g-i | 59b-e | 102.5e-g | 6.8a-d | 18.5fg | 40.4j | 4498.4fg | -0.27 |
| Local check | 87.0a | 145bc | 57de | 113.2b | 6.6c-e | 18.5fg | 46.0b-f | 4510.7fg | 0 |
| Mean  | 80.32 | 139.71 | 59.39 | 105.05 | 6.82 | 19.05 | 45.23 | 4901.88 |  |
| CV | 3.13 | 2.06 | 5.65 | 1.92 | 7.62 | 2.70 | 4.95 | 10.98 |  |
| F test | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* |  |

DH= days to heading; DM= days to maturity; GFP= grain filling period; PH= Plant height (cm); SL= Spike length (cm); SPS = Spikeltes per spike; TKW= Thousand kernel weight (g); GY= grain yield (kg ha -1); YA= yield advantage (%).; \*\*\*= significant at P< 0.001

**Yield and yield components**

Variety Dimtu exhibited a longer spike length (7.3 cm) (Table 3). This variety also had more spikelets per spike (21.3) than all the improved varieties and the local check. Variety Shege had a heavier and significant thousand seed weight (48.8 g) than the local check. The mean grain yield across locations indicated that variety HB 1307 gave high grain yield (6273.1 kg ha -1) and bit all the varieties studied. Generally mean grain yield across locations indicated that six varieties were significantly out yielded the local check *viz* variety HB 1307, Cross 41/98, HB 42, Eh 1493, Dimtu and Ardu 1260B which gave 6273.1, 5690.8, 5540.6,5181.1, 5067.9, 5047.3 kg ha -1 respectively (Table 3). These top yielder varieties gave a yield advantages of 39.07, 26.16, 22.92, 14.86, 12.35 and 11.90 percent respectively compared to the local check.

The mean grain yield of each specific location indicated that improved varieties bit the local check ranged from one at Gedeb, 2014, five at Bule, 2014, and nine at Abera Gelede, 2014 (Table S1-4). This indicates that there are potential varieties of those gave above the local check in each specific location.

**DISCUSSION**

In the present study the results indicated that barley varieties have differed in a wider range of agronomic characters. In this study, two improved varieties Ardu 1260B, HB 42 and the local check took longer days to head from tested varieties while variety Harbu was 17 days earlier to head than the local check. In line with this finding Abera et al. (2019) found varieties Harbu and Dafo were early to head than the local check at West and Kelem Wellega Zones. In disagreement with study Lema et al. (2022) and Tolesa et al. (2019) reported that the local check was early to head and variety cross 41/98 took longer days to head at Diko Tsida Sub Center of Gamo and West Shewa highlands respectively. Similarly, as days to heading variety Ardu 1260B also took longer days to reach physiological maturity than most of the varieties and local check too. In disagreement with this finding Tolesa et al.(2019) found the local cultivar matured later compared to other varieties while Lema et al.(2022) and Mamo (2017) reported that variety HB 42 was late to reach physiological maturity 126 and 144 days respectively than the rest of barley varieties and the local check. But regarding grain filling period variety, HB1307 had a longer grain filling period than the check. In disagreement with this result, an experiment done in West Shewa showed the local check had more grain filling periods than improved varieties (Tolesa et al., 2019). A longer grain filling periods allow photosynthetic components to remain green improving grain filling and leading to good grain yield of post anthesis assimilates which is important in cereals ( Vaezi et al., 2010). Variety Ardu 1260B was the tallest of all the rest of varieties including the check. Not in line with study Mamo (2017) and Lema (2022) found that HB 1307 (116.6 cm) and Dimtu (125.8 cm) were the tallest varieties in an experiment done in Kaffa and Gamo highlands respectively. Generally varieties tested in different agro-ecologies responded differently for agronomic characters.

Regarding yield components characters variety Dimtu exhibited a longer spike length and more spikelets per spike than the local check. In disagreement to this study Lema et al. (2022) reported variety Tiret had the longest spike length than both the improved and local check. The older improved variety Shege had a heavier and significant thousand seed weight than the local check but par with HB 1307, HB 42, and Ardu 1260B. This result was supported by Mamo (2017) who found the highest mean value of a thousand kernel weight recorded from HB 42 (47.7 g). The mean grain yield across locations indicated that variety HB 1307 gave high grain yield (6273.1 kg ha -1) and bit all the varieties studied. In line with this study, Lema et al. (2022) reported that the highest mean grain yield was recorded from HB 1307 (2427.8 kg ha -1). In disagreement with result Mamo et al. (2017) found variety Dirbe exhibited the highest grain yield (4.6 tons ha -1) followed by HB 42 (3.5 ha -1). Generally in this study the mean grain yield across locations indicated that six varieties were significantly out yielded the local check *viz* variety HB 1307, Cross 41/98, HB 42, EH 1493, Dimtu and Ardu 1260B which gave 6273.1, 5690.8, 5540.6,5181.1, 5067.9, 5047.3 kg ha -1 respectively . These top yielder varieties gave a yield advantages of 39.07, 26.16, 22.92, 14.86, 12.35 and 11.90 percent respectively compared to the local check.

**CONCLUSION**

In this study, six wide and four specific adaptable varieties were identified and the evaluated barley varieties showed variation in phenological, yield, and yield component traits. Generally the mean grain yield across locations indicated that six varieties were significantly out yielded the local check *viz* varieties HB 1307, Cross 41/98, HB 42, EH 1493, Dimtu, and Ardu 1260B which gave 6273.1, 5690.8, 5540.6, 5181.1, 5067.9, 5047.3 kg ha -1 respectively. These adapted and top yielder varieties gave a yield advantages of 39.07, 26.16, 22.92, 14.86, 12.35 and 11.90 percent respectively compared to the local check. These varieties are high yielding and wide adaptable across locations and would be popularized and scaled up for production in the tested area and similar agro-ecologies of Southern Ethiopia highlands. For specific adaptation variety, Abdane was one of the high yielding varieties at Bule areas and varieties Shedeho, Agegnehu, and Yedogit were adapted to Abera Gelede highlands but none of these varieties was high yielding across locations and can be recommend for production in their niche where they are best-suited areas. Despite releasing many food barley varieties in the country few have been accessed by farmers with their improved agronomic practices, this is accompanied by low productivity. Promotions of recently released barley varieties are important for barley-growing farmers to easily access them and to increase the production and productivity.

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 **Supplementary Tables**

Table S1. Mean performance of agronomic, yield and yield component traits of late maturing food barley varieties at Bule, 2013

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variety  | DH | DM | GFP | PH | SL | SPS | TKW | GY | YA |
| HB 1307 | 74g | 161b | 87a | 100.4g | 6.9de | 21c | 55a-0d | 6273.1a | 39.07 |
| Shege | 80e | 157cd | 77f-h | 107.3d | 8.4a-c | 24b | 62.0a | 4222.8g | -6.38 |
| HB 42 | 85b | 160b | 75h | 107.3d | 7.7bd | 24b | 57.3a-d | 5544.6bc | 22.92 |
| Ardu 1260B | 86a | 167a | 81cd | 118.8ab | 8.1a-c | 20d | 58.0a-c | 5047.3de | 11.90 |
| Dimtu | 75f | 157d | 82bc | 118.3b | 8.8a | 27a | 53.0b-d | 5067.9de | 12.35 |
| Cross 41/98 | 81de | 151e | 70i | 103.2f | 8.7ab | 22c | 54.3a-d | 5690.8b | 26.16 |
| EH 1493 | 84c | 160b | 77f-h | 107.6d | 6.4e | 19de | 53.0b-d | 5181.1cd | 14.86 |
| Yedogit | 64k | 144gh | 80c-e | 100.8g | 6.9de | 17f | 56.7a-d | 4832.3d-f | 7.13 |
| Estayish | 67i | 145fg | 78d-g | 104.4e | 6.1e | 18e | 58.3a-c | 4387.6fg | -2.73 |
| Tiret | 71h | 142h | 71i | 104.0ef | 8.2a-c | 21c | 48.7de | 4630.6e-g | 2.66 |
| Shedeho | 66j | 142h | 76gh | 100.8g | 6.9de | 17f | 50.0cd | 4631.0e-g | 2.67 |
| Harbu | 63l | 147f | 84b | 112.4c | 7.8a-d | 19d | 57.7a-c | 4300.4g | -4.66 |
| Agegnehu | 67i | 147f | 79c-f | 92.8h | 7.5cd | 19d | 55.3a-d | 4709.6d-g | 4.41 |
| Abdane | 66j | 148f | 82bc | 107.7d | 8.2a-c | 22c | 41.7e | 4498.4fg | -0.27 |
| Local check | 82d | 159bc | 78e-g | 119.5a | 6.3e | 20d | 60.0ab | 4510.7fg | 0 |
| Mean  | 74.0 | 152.5 | 78.5 | 107.0 | 7.5 | 20.6 | 54.7 | 4901.88 |  |
| CV | 0.60 | 0.95 | 1.9 | 0.46 | 7.4 | 2.8 | 8.3 | 10.98 |  |
| F test | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\* | \*\*\* |  |

DH= days to heading; DM= days to maturity; GFP= grain filling period; PH= Plant height( cm); SL= Spike length (cm); SPS ( spikeltes per spike; TKW= Thousand kernel weight (g); GY= grain yield (kg ha -1 ); YA= yield advantage (%).; \*\*\*= significant at P< 0.001; \*\*= significant at P< 0.01

Table S2. Mean performance of agronomic, yield and yield component traits of late maturing food barley varieties at Bule, 2014

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variety  | DH | DM | GFP | PH | SL | SPS | TKW | GY |
| HB 1307 | 92b-d | 147ab | 54a-c | 93.3hi | 5.5c-e | 22b | 50.7b | 7104.0a |
| Shege |  96bc | 142a-c | 46c | 98.9e | 6.5ab | 20de | 49.3c | 5347.1fg |
| HB 42 | 98b | 147ab | 49bc | 95.5f | 5.4e | 20de | 46.0ef | 6161.7b-d |
| Ardu 1260B | 96bc | 147ab | 51a-c | 113.9a | 5.5de | 19ef | 46.7e | 5490.3d-g |
| Dimtu | 93b-d | 137bc | 44c | 107.2b | 6.3a-c | 21d | 48.0d | 6740.0ab |
| Cross 41/98 | 87c-e | 137bc | 50a-c | 93.9gh | 6.5ab | 22b | 46.0ef | 6500.6a-c |
| EH 1493 | 90b-e | 144ab | 54a-c | 87.2j | 6.6ab | 24a | 44.7gh | 5408.4e-g |
| Yedogit | 107a | 150a | 43c | 101.1d | 7.0a | 22bc | 42.7i | 5198.4g |
| Estayish | 90b-e | 140a-c | 50a-c | 92.7i | 6.2a-d | 21cd | 45.3fg | 5941.3c-f |
| Tiret | 81e | 142a-c | 61a | 94.9fg | 5.6c-e | 18g | 48.0d | 5939.0c-f |
| Shedeho | 96bc | 140a-c | 44c | 95.0f | 6.6ab | 22bc | 42.0i | 5928.4c-f |
| Harbu | 81e | 132c | 51a-c | 92.5i | 6.0b-e | 19f | 44.7gh | 5817.4c-g |
| Agegnehu | 84de | 144ab | 60ab | 94.6fg | 5.3e | 17h | 52.7a | 6070.1b-e |
| Abdane | 81e | 132c | 51a-c | 93.8gh | 6.4ab | 22b | 46.0ef | 6627.8ab |
| Local check | 98b | 142a-c | 44c | 104.6c | 6.ab-e | 20de | 44.0h | 5421.7e-g |
| Mean  | 91.3 | 141.5 | 50.2 | 97.3 | 6.1 | 20.8 | 46.4 | 5979.74 |
| CV | 5.29 | 3.67 | 11.68 | 0.61 | 6.72 | 2.67 | 0.91 | 6.10 |
| F test | \*\*\* | \*\* | \* | \*\*\* | \*\*\* | \*\*\* | \*\* | \*\*\* |

DH= days to heading; DM= days to maturity; GFP= grain filling period; PH= Plant height( cm); SL= Spike length (cm); SPS ( spikeltes per spike; TKW= Thousand kernel weight (g); GY= grain yield (kg ha -1 ); YA= yield advantage (%).; \*\*\*= significant at P< 0.001; \*\*= significant at P< 0.01; \*= significant at P< 0.05

Table S3. Mean performance of agronomic, yield and yield component traits of late maturing food barley varieties at Gedeb, 2014

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variety  | DH | DM | GFP | PH | SL | SPS | TKW | GY |
| HB 1307 | 78d | 129b | 51b | 108.3d | 8.0a | 18a | 43.3c | 6838.1a |
| Shege | 77de | 120d | 43ef | 100.0gh | 6.3c | 16bc | 44.7a | 3716.4fg |
| HB 42 | 82c | 128c | 46d | 100.3g | 6.0c | 15de | 44.0b | 4462.9cd |
| Ardu 1260B | 86a | 133a | 47cd | 13.7b | 6.7bc | 18a | 44.0b | 4631.4c |
| Dimtu | 82c | 129b | 48c | 115.7a | 6.7bc | 17b | 43.3c | 3779.6fg |
| Cross 41/98 | 77de | 121d | 44e | 103.7f | 6.3c | 16bc | 42.0d | 5470.7b |
| EH 1493 | 77de | 129b | 52b | 97.7i | 7.7a | 18a | 40.0e | 4693.7c |
| Yedogit | 76e | 130b | 53a | 115.7a | 6.3c | 16bc | 44.0b | 4693.3c |
| Estayish | 72h | 109i | 38i | 87.7j | 5.7c | 14e | 34.0j | 3455.1gh |
| Tiret | 77de | 118e | 41h | 106.7e | 7.3ab | 14e | 36.0i | 4291.0c-e |
| Shedeho | 73g | 114f | 42gh | 100gh | 6.3c | 15de | 38.0g | 3716.1fg |
| Harbu | 68i | 112h | 43ef | 99.7gh | 6.0c | 15de | 37.3h | 3266.3h |
| Agegnehu | 71h | 113g | 42fg | 99.3h | 6.3c | 16bc | 38.7f | 3957.9ef |
| Abdane | 75f | 119e | 43ef | 97.7i | 5.7c | 13f | 38.0g | 3303.4h |
| Local check | 85b | 128c | 44e | 112.7c | 6.3c | 17b | 42.0d | 4120.0d-f |
| Mean  | 77.1 | 122.2 | 45.1 | 103.9 | 6.5 | 15.9 | 40.6 | 4293.06 |
| CV | 0.72 | 0.40 | 1.51 | 0.52 | 7.93 | 2.97 | 0.82 | 5.31 |
| F test | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* | \*\*\* |

DH= days to heading; DM= days to maturity; GFP= grain filling period; PH= Plant height( cm); SL= Spike length (cm); SPS ( spikeltes per spike; TKW= Thousand kernel weight (g); GY= grain yield (kg ha -1 ); YA= yield advantage (%).; \*\*\*= significant at P< 0.001

Table S4. Mean performance of agronomic, yield and yield component traits of late maturing food barley varieties at Abera Gelede, 2014

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Variety  | DH | DM | GFP | PH | SL | SPS | TKW | GY |
| HB 1307 | 83a | 150a | 67a | 110c-f | 7.5a-c | 20bc | 42.7a | 7765.1a |
| Shege | 82a | 149a | 67a | 106.7eg | 6.5cd | 20bc | 39.3a-e | 5093.0c |
| HB 42 | 84a | 148a | 64a-c | 108.9c-g | 7.4a-c | 19d | 42.0ab | 7938.9a |
| Ardu 1260B | 84a | 147a | 63a-d | 128.3a | 7.7ab | 21ab | 39.3a-e | 7245.6ab |
| Dimtu | 83a | 149a | 66a-c | 115.5bc | 7.4a-c | 21ab | 40.7a-d | 6790.5a-c |
| Cross 41/98 | 83a | 148a | 66a-c | 115.0b-d | 7.4a-c | 22a | 38.7b-e | 7869.6a |
| EH 1493 | 85a | 147a | 63a-d | 111.6c-f | 7.9a | 21ab | 41.3a-c | 7188.1ab |
| Yedogit | 84a | 146a | 63a-d | 122.2ab | 6.9a-d | 18e | 38.7b-e | 6564.2a-c |
| Estayish | 71cd | 134c | 63a-d | 106.6e-g | 7.1a-c | 17ef | 40.7a-d | 5693.3bc |
| Tiret | 79b | 137b | 58d | 101.6g | 6.7b-d | 15h | 37.3de | 5683.2bc |
| Shedeho | 73c | 138b | 65a-c | 105fg | 5.9d | 21ab | 36.0e | 6115.2a-c |
| Harbu | 68e | 131c | 64a-c | 113.9ce | 6.5cd | 17ef | 36.0e | 5404.5bc |
| Agegnehu | 71d | 133c | 62b-d | 107.8d-g | 7.4a-c | 18e | 40.0a-d | 6451.1a-c |
| Abdane | 71d | 132c | 61cd | 111.1c-f | 6.9a-d | 16gh | 36.0e | 5449.1bc |
| Local check | 84a | 149a | 65a-c | 116.1b-c | 7.7ab | 18e | 38.0c-e | 5377.6bc |
| Mean  | 78.9 | 142.5 | 63.7 | 112.0 | 7.1 | 18.9 | 39.1 | 6441.94 |
| CV | 1.79 | 1.25 | 3.74 | 3.61 | 7.80 | 2.36 | 4.52 | 16.17 |
| F test | \*\*\* | \*\*\* | \*\* | \*\*\* | \*\* | \*\*\* | \*\* | \* |

DH= days to heading; DM= days to maturity; GFP= grain filling period; PH= Plant height( cm); SL= Spike length (cm); SPS ( spikeltes per spike; TKW= Thousand kernel weight (g); GY= grain yield (kg ha -1 ); YA= yield advantage (%).; \*\*\*= significant at P< 0.001; \*\*= significant at P< 0.01; \*= significant at P< 0.05