Bread Wheat Varietal Development and Release in Southeastern Highlands of Ethiopia

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Abstract: Four improved bread wheat varieties; Mandoyu (WORRAKATTA/PASTOR), Sanate (14F/HAR1685), Obora (UTIQUE96/FLAG-1) and Dambel (AGUILAL/3/PYN/BAU//MILAN) are developed from ICARDA materials and released in 2014 and 2015, respectively for highland and mid altitude areas of Bale and similar agro-ecologies. The new varieties were tested along with three standard checks (Madawalabu, Sofumer and Tusie) and one local check (Hollandi) at three environments in 2011 to 2012 and 2012 to 2013, respectively during main cropping seasons. The two years data of regional variety trial combined over locations and years provide the newly released varieties showed that superior in grain yield performance, stability, and wide adaptation. The four newly released varieties have good protein content, good physical grain quality, resistant to stem rust, moderately susceptible to yellow rust, moderately resistant to septoria leaf blotch and comparable for leaf rust disease with the checks. The variety Mandoyu, Sanate, Obora and Dambel have been demonstrated and are being cultivated by farmers for production purpose. Hence, the cultivation of these newly released improved bread wheat varieties in the highland and mid altitude areas of major wheat growing environments of the country is highly recommended. This new variety given local name Mandoyu, Sanate, Obora and Dambel, respectively.

Keywords: Wheat Variety, Grain Yield, Grain Quality, Protein Content, Wheat Diseases

1. Introduction

Wheat (Triticum aestivum L.) is one of the most important crops in the world in production and nutrition. Annually, wheat is produced on 224.53 million hectares of land and 672.2 million metric tons of wheat is produced in the world [10]. In Ethiopia, wheat is one of the most important cereal crops widely cultivated. It is cultivated both in bi-modal and uni-modal rain fall areas. Bread wheat (Triticum aestivum L.) and durum wheat (T. turgidum L. var. durum) are the two species which are mainly cultivated by small scale farmers in Ethiopia. It ranks fourth in area coverage next to teff, maize and sorghum, respectively [7]. It is the main staple food for about 36% of the Ethiopian population [4], [5]. Arsi and Bale highlands are the major wheat producing regions of Ethiopia [2] and are deemed to be the wheat belts of East Africa. The area under wheat production is estimated to be about 1.6 million hectares, which makes the country the largest wheat producer in sub-Saharan Africa [6], [8]. Wheat production constrained by various biotic and abiotic factors. Among the biotic factors, fungal diseases are one of the most important biotic constraints threatening wheat production in Ethiopia [1], [9]. Recently, rusts (stem, yellow and leaf rust) and

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septoria leaf blotch and fusarium head blight are significantly threatening wheat production in most of wheat producing agro-ecologies [3]. To alleviate these constraints confronting wheat production, wheat breeding program at Sinana has been working on development of wheat varieties with high yield potential and resistance to major wheat diseases. Development of high yielding varieties requires a thorough knowledge of the existing genetic variation for yield and its components. The successful process of wheat breeding is based on the knowledge of characteristics of genotypes, environment and its interaction. The ideal cultivar for high grain yield or for any other desirable traits needs to express genetic potential with low value of variance in different environmental factors of growing. Therefore, generating more new improved production technologies on wheat must be continues to contribute in food self-sufficiency and sustainable agriculture and could be source of income generation for the local farmers. The objective of the present study was to develop high yielding and disease resistant bread wheat varieties suitable for optimum environments.

2. Materials and Methods

2.1. Breeding Material and Its Background

Initially more than 2000 bread wheat genotypes received from ICARDA and evaluated under field conditions in augmented design. The best promising genotypes were selected on the basis of maturity, diseases and advanced to preliminary yield trial for further test.

2.2. Experimental Site and Field Experiment

The experiment was conducted at three locations for two years (2011 to 2012) and the other experiment was also carried out at the same locations for two consecutive years (2012 to 2013) during main cropping seasons. One of the experiment was conducted at the research farm of Sinana Agricultural Research Center, and the other three sites in the farmer’s fields; Robe, Goba and Agarfa. The experiment was conducted from regional variety trial till to the verification trial in 2011 to 2012 and 2012 to 2013, respectively at each locations on vertisol clay-loam soil under rain fed conditions during meher seasons (August-January). Sinana Research Center (7°N latitude and 40°E longitude; and 2400 m a.s.l) is located 463 km southeast of Addis Ababa and east of Robe town of Bale zone. Robe is located 33 km from Sinana in the southeast direction. Goba is located 37 km from Sinana and about 14 km from Robe in the south west direction, and Agarfa is located 63 km from Sinana and 81 kg/hl (Table 1). This variety is resistant to stem rust and moderately susceptible to yellow rust.

3. Results and Discussion

3.1. Varietal Characteristics

Mandoyu (WORRAKATTA/PASTOR) is the improved bread wheat variety released in 2014 for mid and highlands of Bale and similar agro-ecologies. This variety is characterized by an erect growth habit and compact ear types. It has white seed color. On average this variety required 68 days for heading, 139 days need to reach physiological maturity and the average plant height is 85 cm (Table 1). The average weight of thousand kernel is 36.2 and test weight is 81 kg/hl (Table 1). This variety is resistant to stem rust and moderately susceptible to yellow rust.

Sanate (14F/HAR 1685) is the newly released bread wheat variety in 2014 for highlands of Bale and similar agro-ecologies. The variety has compact ear types and erect growth habit. It has amber seed color. On average the variety needs 71 days to heading and 141 days requires to reach physiological maturity, with the average plant height is 102 cm (Table 1). The average weight of thousand kernel of this new variety is 39.5 and test weight is 80 kg/hl (Table 1). The variety is resistant to stem rust and moderately susceptible to yellow rust.
Obora (UTIQUE96/FLAG-1) is the newly released bread wheat variety in 2015 for mid and highlands of Bale and similar agro-ecologies. The variety is characterized by having an erect growth habit and compact ear types. It has white seed color. Obora variety on average needs 73 days to heading and 144 days to reach physiological maturity, with the average plant height is 94 cm (Table 2). The average weight of thousand kernel of this new variety is 39 gram and test weight is 82.1 kg/hl (Table 2). This variety is resistant to major wheat diseases.

3.2. Grain Yield Performance

Mandoyou (WORRAKATTA/PASTOR) is characterized by having higher seed grain than the standard check so far released. It has better grain yield advantage of 20%, 16% and 36% over standard check Sosfumer, Tusie and local check Hollandi, respectively (Table 1). The variety gives grain yield of 4.9 to 5.8 t ha\(^{-1}\) on the research field whereas it gives 2.7 to 4.2 t ha\(^{-1}\) on farmers’ field (Table 3).

Dambal (AGUILAL/3/PYN/BAU/[MILAN) is the improved bread wheat variety released in 2015 for highland of Bale and similar agro-ecologies. This variety is characterized by having slightly red to amber seed color. It has an erect growth habit and compact ear types. The variety requires 69 days to heading and 142 days needs to reach physiological maturity and with the average plant height being 101 cm (Table 2). The average weight of thousand kernel is 41.2 and test weight is 81.7 kg/hl (Table 2). This variety is resistant to major wheat diseases.

**Table 1. Mean grain yield, other agronomic traits and diseases reaction of Mandoyou, Sanate and the checks in multi-location test during 2011-2012.**

| SN  | Genotypes                          | Dh  | Dm  | Phh | Tkw | Tw  | Gy  | Yr  | Sr  | Lr  | Sep |
|-----|------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1   | WORRAKATTA/PASTOR (Mandoyou)       | 68  | 139 | 85  | 36.2| 81.5| 4275.5| 10ms| Tr  | 5ms | 82  |
| 2   | 14F/HAR 1685 (Sanate)              | 71  | 141 | 102 | 39.5| 80  | 4238.6| 5ms | 5ms | 5ms | 81  |
| 3   | Sosfumer (Standard check)          | 67  | 136 | 97  | 39.8| 72  | 3571.5| 5ms | 30s | 5ms | 82  |
| 4   | Tusie (Standard check)             | 68  | 139 | 98  | 34.6| 73  | 3684  | 10ms| 50s | 5ms | 82  |
| 5   | Hollandi (Local check)             | 66  | 138 | 119 | 40.4| 72  | 3126.2| 60s | 30s | 5ms | 84  |

Dh= days to heading, Dm= days to maturity, Phh= plant height (cm), Tkw= thousand kernel weight (g), Tw= test weight (kg/hl), Gy= grain yield (kg/ha), Yr= yellow rust, Sr= stem rust, Lr= leaf rust, Sep= Septoria.

**Table 2. Mean grain yield, other agronomic traits and diseases reaction of Obora, Dambal and the checks in multi-location test during 2012-2013.**

| SN  | Genotypes                          | Dh  | Dm  | Phh | Tkw | Tw  | Gy  | Yr  | Sr  | Lr  | Sep |
|-----|------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1   | ICARDA ELITE SRR-ON Summer 09      | 73  | 144 | 94  | 39  | 82.1| 4253.8| 5ms | 10ms| 81  |
| 2   | 14F/HAR 1685 (Sanate)              | 69  | 142 | 101 | 41.2| 81.7| 4578.7| 5mr | 10ms| 81  |
| 3   | Madawalabu (Standard check)        | 69  | 143 | 101 | 42  | 78.8| 3797.1| 5mr | 40s | 94  |
| 4   | Hollandi (Local check)             | 65  | 140 | 116 | 38  | 79.4| 3239.8| 5mr | 40s | 87  |

Dh= days to heading, Dm= days to maturity, Phh= plant height (cm), Tkw= thousand kernel weight (g), Tw= test weight (kg/hl), Gy= grain yield (kg/ha), Yr= yellow rust, Sr= stem rust, Lr= leaf rust, Sep= Septoria.

**Table 3. Combined mean grain yield and other agronomic traits of bread wheat regional variety trial over years (2011-2012) and over locations (Sinana, Robe and Goba).**

| SN  | Genotypes                          | Dh  | Dm  | Phh | Tkw | Tw  | Gy  | Yr  | Sr  | Lr  | Sep |
|-----|------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1   | SAKER/5/RBS/ANZA/KVZ/HYS/’YMH/TOB/4’ BOW’S/PEWIT3/7/ANTA-1 | 69.3 | 137.11 | 82.78 | 36.12 | 68.3 | 3767.1 | defg | |
| 2   | SAMAR-8/KAUZ’S/’CHAM-4/SHUHA’S’ | 67.11 | 137.78efg | 92.50 | 34.22 | 68.9 | 3747.2 | defg | |
| 3   | EALME4SA-167 | 67.22 | 135.22i | 89.61 | 37.71 | 68.8 | 3720.9 | efg | |
| 4   | SKAUA/BV92 | 70.28 | 138.89de | 99.67 | 37.13 | 69.0 | 3814.9 | defg | |
| 5   | WORRAKATTA/PASTOR (Mandoyou)      | 68.39 | 138.83defg | 85.33 | 36.22 | 70.6 | 4275.5 | a | |
| 6   | UTQUE96/3/PYN/BAU/[MILAN | 74.78 | 139.39i | 91.61 | 39.68 | 71.5 | 3966.3 | bcd | |
| 7   | UTQUE96/3/PYN/BAU/[MILAN | 70.94 | 139.06de | 93.89 | 40.55 | 71.8 | 4276.3 | a | |
| 8   | AGUILAL/3/PYN/BAU/[MILAN | 66.72 | 137.94efg | 91.28 | 41.24 | 71.1 | 4104.5 | abc | |
| 9   | ETBW5570 | 68.06 | 135.11i | 91.00 | 41.13 | 70.1 | 4283.4 | a | |
| 10  | ETBW5572 | 67.50 | 137.89efg | 99.67 | 39.09 | 69.3 | 4183.0 | ab | |
| 11  | NST32/HERR/[MILAN/SHAA] | 69.85 | 141.50c | 94.89 | 41.58a | 71.2 | 4074.8 | ab | |
| 12  | VEE/JPN/2/TU3/2/[MILAN/KAUZ | 86.58 | 137.61fg | 94.22efg | 40.28b | 72.3 | 4155.9 | abc | |
| 13  | 15F/HAR710 | 70.44 | 141.94bc | 112.67 | 38.92 | 72.0 | 3931.5 | cde | |
| 14  | 14F/HAR1685 (Sanate) | 75.11 | 142.94ab | 103.83 | 36.02 | 71.5 | 4238.6 | a | |
| 15  | F6-MR-CA-ETH-SRR | 72.22 | 143.22a | 93.50 | 36.91 | 72.4 | 3769.3 | defg | |
| 16  | Sosfumer (standard check)          | 67.22 | 135.94i | 96.83 | 39.87 | 72.0 | 3571.5 | a | |
| 17  | Tusie (standard check)             | 68.44 | 139.22d | 98.78 | 34.58i | 73.0 | 3684.0 | fg | |
Obora (UTIQUE96/FLAG-1) has high grain yield than the standard check so far released. It has better grain yield advantage of 12% over standard check Madawalabu and 31.3% over local check Hollandi (Table 2). This variety gives grain yield of 4.68 to 6.31 t ha\(^{-1}\) on the research field whereas it gives 3.3 to 3.75 t ha\(^{-1}\) on farmers’ field (Table 4).

### Table 4. Combined mean grain yield and other agronomic traits of bread wheat regional variety trial over years (2012-2013) and over locations (Sinana, Goba and Agagarra).

| SN | Genotypes | Dh** | Dm** | Pht** | Tkw** | Tw | Gy** |
|----|------------|------|------|-------|-------|----|------|
| 1  | 1 | 69.39** | 67.87** | 91.72** | 35.49** | 18.9 | 3900.3** |
| 2  | 2 | 66.56** | 64.11** | 94.00** | 35.26** | 20.7 | 4041.6** |
| 3  | 3 | 70.39** | 64.11** | 77.28** | 37.32** | 20.1 | 3865.7** |
| 4  | 4 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 3851.5** |
| 5  | 5 | 72.67** | 64.11** | 91.44** | 31.22** | 20.1 | 4052.4** |
| 6  | 6 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4196.3** |
| 7  | 7 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 8  | 8 | 71.17** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 9  | 9 | 69.44** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 10 | 10 | 72.67** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 11 | 11 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 12 | 12 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 13 | 13 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 14 | 14 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 15 | 15 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 16 | 16 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 17 | 17 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 18 | 18 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 19 | 19 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 20 | 20 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 21 | 21 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 22 | 22 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 23 | 23 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 24 | 24 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| 25 | 25 | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| Mean | 66.27** | 64.11** | 91.44** | 31.22** | 20.1 | 4340.9** |
| SE | 0.85 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 |
| LSD (SE) | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 |

*Dh: days for heading, Dm: days to maturity, Phl: plant height (cm), Tkw: thousand kernel weight (gm), Tw: test weight (kg/ha), Gy: grain yield (kg/ha), Sr: stem rust (%), Yr: yellow rust (%), Lr: leaf rust (%), S: susceptible, MS: moderately susceptible, MR: moderately resistant, Tr: trace, Trms: trace with moderately susceptible, Trmr: trace with moderately resistant, R: resistant, CV (%): coefficient of variations, SE: standard error of the mean, LSD: least significant differences, ++ Means within each column followed by the same letter are not significantly different from each other based on the 0.05 probability level of LSD.

3.3. Reaction to the Major Wheat Diseases and Quality Traits

The newly released bread wheat varieties resistance / tolerance to stem rust, moderately susceptible to yellow rust, moderately resistance to septoria leaf blotch and comparable for leaf rust disease with the checks (Table 1 and 2). The quality parameters indicates that the newly released variety Obora, Sanate, Mandoyu and Dambal have good percentage of protein content and gluten content, which ranges from 12.1 to 15.9% and 25.9 to 37.4%, respectively (Table 5).


### Table 5. Quality parameters of improved bread wheat varieties recently released from SARC.

| SN | Variety                     | Quality parameters | Zeleny index (ml) | Moisture content (%) | Protein (%) | Gluten (%) | HLW* (kg hl⁻¹) | TKW* (g) |
|----|-----------------------------|--------------------|-------------------|----------------------|-------------|------------|----------------|----------|
| 1  | Senate (14F/HAR1685)        | 39.1               | 29.6              | 12.7                 | 13.9        | 58.9       | 75.2           |          |
| 2  | Mandooyu (WORRAKATTA/PASTOR | 32.5               | 31.1              | 11.5                 | 13.7        | 63.6       | 80.0           |          |
| 3  | Obora (UTIQUE96/FLAG-1)     | 37.2               | 37.4              | 11.0                 | 15.9        | 79.3       | 80.0           |          |
| 4  | Dambal (AGUILAL/3/PYN/BAU//MILAN) | 46.3             | 25.9              | 11.7                 | 12.1        | 48.1       | 83.6           |          |

*TKW*= thousand kernel weight, HLW*= hectoliter weight, SN= serial number.

#### 3.4. Adaptation

Mandooyu variety released for mid and high altitude areas of Bale whereas Sanate variety released for highlands of Bale and similar agro-ecologies. These two improved bread wheat varieties perform very well in area having an altitude 2200 to 2500 and 2300 to 2600 m a.s.l, respectively with the annual rainfall of 750-1500 mm. The two improved bread wheat varieties are better if planting is done from mid-June to late August based on the agro-ecology of the area.

Obora and Dambal varieties are released for highlands of Bale and similar agro-ecologies. These two improved bread wheat varieties perform very well in area having an altitude 2000 to 2400 m a.s.l with the annual rainfall of 750-1500 mm. Both two improved bread wheat varieties are better if planting is done from mid-June to early September based on the agro-ecology of the area.

#### 4. Conclusions

Mandooyu, Sanate, Obora and Dambal are the best varieties identified and verified along with standard checks and local check in multi-location trials across the testing environments with superior in grain yield performance, yield stability and wide adaptation. They have better agronomic performance with resistance to stem rust disease compared to the standard checks. Hence, cultivation of the new varieties are recommended in major wheat growing regions of the country having similar agro-ecologies with the testing environments.

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