

Adaptation and Promotion of Improved Beard Wheat *Triticum aestivum* L Varieties Under Irrigation in North West Amhara Ethiopia

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Abstract

Twenty-two bread wheat varieties eight of them were heat tolerant and fourteen bread wheat varieties released under rain feed were evaluated in two sets for adaptation and promotion of the best-adapted varieties (2020-2021) cropping season under irrigation at Metema and Belesa districts. The objective of this experiment was to identify and promote the best adapted, high yielder, and heat tolerance bread wheat varieties for different agro ecology irrigated production areas of the region. The experiments were conducted one year for a variety adaptation trial and a second year for demonstration of the best adapted, high yielding, and heat tolerance varieties from the two sets in the selected farmers field under irrigation. The analysis of variance in both sets of experiments indicated that there was a highly significant difference ($p < 0.01$) among the varieties for days to heading, days to maturity, number of spikelets per spike, number of seeds per spike, biological yield, grain yield, thousand seed weight and there was a significant difference among the varieties in plant height and spike length. The average mean of days to maturity for both sets was 92 days ranging from 80-96 days for heat tolerance & 83-97 days for released under rain feed. Early maturity was observed on

achieve the required impact and improve the livelihoods of people. It is estimated that the average productivity of wheat is increased from 28 quintals/ha to 50 quintals/ha in rain-fed and irrigation farming systems respectively predicting that wheat self-sufficiency can be achieved while cultivating the crop using irrigation [6]. Which agrees with the approval that irrigation agriculture improves agricultural productivity [7].

Nowadays, irrigation farming is identified as an important catalyst for increased agricultural growth in Africa [8]. And expanding the countries' irrigation potential can improve agricultural productivity and extend annual growing seasons reducing poverty, food insecurity, and import dependency with an individual and the collective action by governments, the private sector, and communities in rural and urban areas [9].

It has been also confirmed that bread wheat cultivation under irrigation has a positive impact on the crop's yield [7] directing the possibility of improving the current national rain-fed wheat productivity (2.8 ton/ha which is lower than the world average of 33 quintals/ha) by using improved irrigation wheat cultivation techniques that the government of Ethiopia has embarked on its goal to achieve wheat self-sufficiency within 3-5 years by expanding production in the irrigable lowland areas and increasing productivity in the rain-fed agro-ecologies of Ethiopia [10]. During the 2020/2021 cropping season, project-based irrigated wheat production has been successfully carried out in 12 woredas of Amhara regional state (on almost 5,000 hectares of farming land) and 21 woredas (on almost 300,000 hectares of farming land) of Oromia regional state.

The wheat research system of Ethiopia has been working to generate yield enhancement of improved varieties along with their full production packages to assist wheat-producing farmers of the country. Ethiopian Institute of agricultural research in collaboration with its strategic partners has long been striving to change the production system of wheat by developing its production technologies suitable for the irrigated lowland areas of the country in sequence with cotton and soybean by showing that the irrigated wheat in Ethiopia is the untapped resource. Werer agricultural research center of the Ethiopian agricultural research center is the coordinating center for lowland irrigated wheat research and with the effort of the research teams working on the center's irrigated wheat research program and other collaborative staff of the institute seven bread wheat and one durum wheat lowland irrigated varieties have been released & it has been shown that improved packages of high-yielding, heat, and stress-tolerant wheat varieties could yield up to 6.5 tons per hectare

in hot lowland irrigated areas of Ethiopia. Therefore, the objective of this study was to identify and demonstrate the best adapted and heat tolerance bread wheat varieties for different agro-ecology irrigated production areas of the region.

Materials and Methods

Demarcation of the study area

Field experiments were conducted in the lowland of West Gondar at Metema and Belesa for two consecutive years (2020-2021), one year for adaptation and the second year for demonstration irrigation seasons, and in the mid-land of Central Gondar at Belesa for one year (2022) irrigation season. The first area is located with a latitude of 12° 38' N and a longitude of 36° 41' E at an altitude of 760 masl. The second area is located with a latitude of 13° 12' N and a

application system of fertilizer was all NPS and half urea was applied at planting and the rest of urea was applied at the full tillering stage of the crop growth. All appropriate agronomic practices such as weeding, watering, and protection management practices were done as the crop required. The irrigation was applied at 7-10 days intervals using the furrow method. Irrigation was provided using a river stagnant water resource to provide the essential moisture for normal crop growth.

Therefore, the amount of irrigation water to irrigate each experimental plot was applied using generator and pump irrigation, which was installed in the experimental site and the amount of water was measured using a soil squeezed method to test soil moisture manually and visual soil texture observation.

Data analysis

Statistical analysis was done using SPSS 20.0.

Days to heading (days): The number of days was recorded from the date of emergence to the stage when the spikes of 50% of the plants are fully visible (exserted). **Grain filling period (days):** The grain filling period in days was computed by subtracting the number of days to heading from the number of days to maturity. **Days to physiological maturity (days):** It was calculated as the number of days from emergence to 95% maturity that is the number of days to maturity minus the number of days to emergence.

Statistical analysis was done using SPSS 20.0.

Plant height (cm): The average height of ten plants randomly taken from each plot at physiological maturity and measured from the ground to the tip of the panicle excluding the awns. **Biological yields (kg/ha):** It was recorded by weighing the total above-ground yield harvested from the four central rows of each experimental plot at the time of harvest.

Thousand kernels weight (gm): The weight of one thousand randomly

for biological yield in heat tolerance bread wheat varieties while non-significant variation from rain fed varieties. The mean value of biological yield for heat-tolerance tested wheat varieties is 13147.82kg/ha. The highest biological yield was recorded from variety Luci (14603 kg/ha) followed by Fentale-2 and Amibara-1 (14151 & 14024 kg/ha) respectively. While the lowest biological yield is obtained from the variety Ardi (10032 kg/ha) followed by Amibara-2 and Gambo (12048 & 12937) respectively. This result indicated/confirmed that heat tolerance bread wheat varieties were more favorable, productive, and high-yielding varieties in the lowland areas of both in biological and grain yield as compared to rain fed varieties.

Grain yield (t/ha)

There was a highly significant difference ($p < 0.001$) among the tested varieties in both sets in grain yield (Tables 3 & 4). Grain yield was taken after the harvest of wheat genotypes and measured at the standard moisture content (12.5) of wheat. The mean grain yield heat tolerance varieties were 5670.81kg ha⁻¹ & 3953kg ha⁻¹ in rain fed. In heat tolerance varieties the highest grain yield was observed from variety Werer-2 (6212.80kg/ha) followed by varieties Fentale-2 (6195.10), Luci (5667.60 kg ha⁻¹), and Ogolcho (6093 kg ha⁻¹) followed by variety Adet 1 and Wane (5220 and 4334 kg ha⁻¹) in rain fed respectively. While the lowest grain yield was found to be variety Amibara-2 (5167.50kg ha⁻¹) followed by varieties Fentale-1 (5436.80), Ardi, (5526.70kg ha⁻¹) in heat tolerance varieties and kingbird (2814 kg ha⁻¹) followed by varieties Hidasie and Alidoro (2820 and 3125 kg ha⁻¹) in rain fed respectively (Tables 3 & 4), this may be due to their lowest number of plant height, spikelet length, number of spikes per spike and number of normal kernels per spike. While the reasons for getting the highest mean grain yields from these varieties are due to their highest effective tiller production, plant height, spikelet length, number of spikes per spike, number of normal kernels per spike, and thousand kernels weight. This result coincides with the result reported by in which yield attributes of cereal crops consists of the number of panicles per unit area, the number of spikelets (florets) per panicle, the percent (ripened) spikelet, and the thousand grain weight. Among all the yield attributes of wheat, panicle number per m² is highly correlated with grain yield and it is the most important factor that causes variation in grain yield. They have also shown earlier times of heading and maturity periods. This confirmed the result of. It found early heading

genotypes could perform better compared to latter heading cultivars where heat stress or high temperature occurred after anthesis due to the reason that early heading cultivars have a longer post-heading period enabled them to have greater grain filling period and completed their grain filling earlier when the air temperature is lower which is more favorable by escaping the most severe effects of heat stress compared to later heading genotypes (Table 4).

Thousand Kernels' weight (g)

Thousand Kernels' weight showed a highly significant difference ($p < 0.001$) among the tested varieties. The mean thousand Kernels weight was 38.81gm and ranged from 35.14gm to 42.09gm (Table 3).

The highest thousand Kernels weight was observed in variety Fentale-2 and Ardi (42.59 and 42.09gm) followed by the varieties Gambo, Amibara-2, Fentale-1, and Luci (41.97, 37.92, 36.40, and 36.11gm) respectively. While the lowest thousand Kernels weight was observed in varieties Amibara-1 and Werer-2 (35.89 and 35.14gm), respectively. According to the rain fed bread wheat varieties the highest thousand seed weight values were obtained from variety Dendea (43.9 g) and Ogolcho (42.7 g) while the lowest thousand seed weight were recorded from varieties Kingbird (29.7gm followed by variety Wane (33.3gm).

Thousand seed weights increased early sowing date might be due to the suitable and longer environmental conditions for vegetative growth, which resulted in the active photosynthesis and maximum translocation of assimilates to the grains and thus had heaviest grains. These results are in agreement with those obtained by. Who reported that under late sowing, a reduction in 1000-grain weight could be attributed to the reduction in grain filling period. Flour industrialists attach special importance to thousand seed weight since there is a significant positive correlation between this trait and flour yield.

Correlation coefficients

Correlation coefficients between the different pair of yield traits of the tested wheat varieties were calculated to find out the relationship among the various yield traits studied as presented in below, (Figures 1 & 2).

As shown in the above figure, grain yield shows a positive and highly significant correlation ($P < 0.01$) with biological yield and thousand seed weight while it shows a non-significant ($p < 0.05$) correlation with the

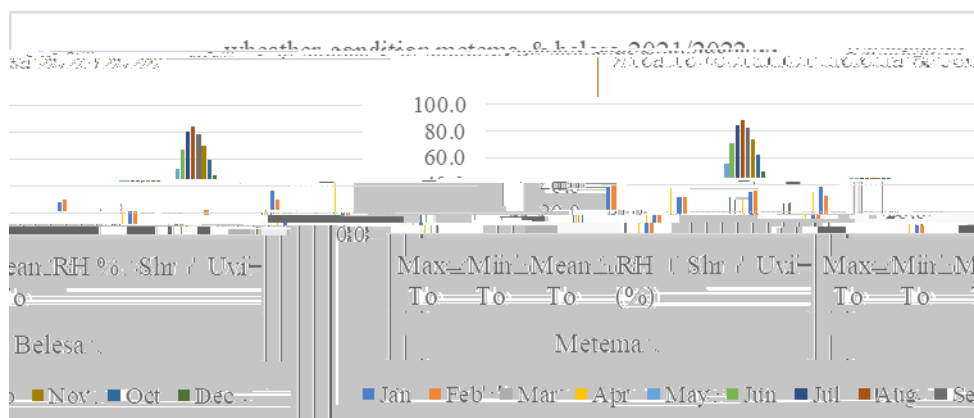


Figure 1: Graphical representation of weather conditions in 2020/2021 at Metema and Belesa districts.

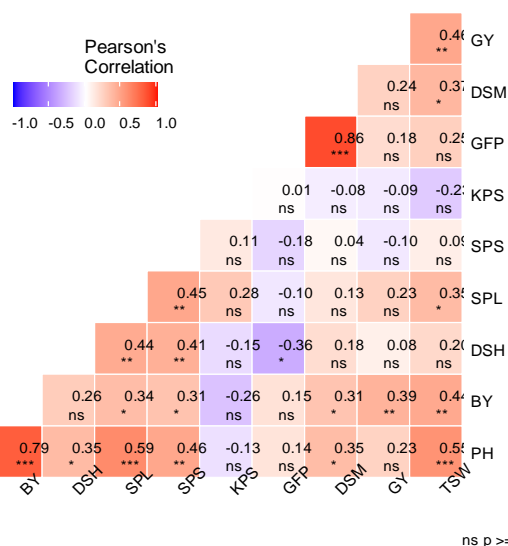


Figure 2 The correlation of traits among the tested bread wheat varieties under irrigation.

date of heading, spike length, number of spikelet per spike and number of kernels per spike. Similarly, a thousand kernels weight showed a positive and highly significant correlation ($P < 0.05$) with plant height, biological yield, days to maturity, mean grain yield, and spikelet per spike of the tested varieties. This result is in agreement with the result of Blanco et al. (2001) who found a significant positive correlation between thousand seed weight and grain yield ($p < 0.05$) in four out of six populations of hexaploidy wheat. There was also a highly significant ($0 < 0.01$) correlation ($r = 0.55$, $r = 0.59$, $r = 0.79$ & $r = 0.46$) between plant height with thousand seed weight, spike length and biological yield and spikelet per spike which is also similar to the finding of. However, mean grain yield was positively but non-significantly ($p < 0.05$) correlated ($r = 0.23$) with spike length which is in contradiction with the result of. Who reported as spike length was negatively correlated with grain yield ($r = -0.13$). Therefore, these traits could be used as indirect selection traits for grain yield according to the significance correlation suggestion.

3.2.2. Farmers Research Extension Group (FREG)

Farmers Research Extension Group (FREG): Two FREGs were established in Metema and Belesa Districts. The FREG members have evaluated the technology based on their crop selection criteria.

Training: On-farm practical training was given to participant farmers and stakeholders about wheat production under irrigation (Table 4).

Field evaluation aimed were conducted at each district with the collaborations of WOA and Gondar Agricultural Research Center. The field day was organized at the maturity stage of the crop. During the field day, stakeholders were involved like farmers, governmental officials, and different experts and they discussed the opportunities and challenges of wheat production and marketing under irrigation (Table 5).

3.2.3. Technology evaluation

Technology evaluation is a very important task to increase farmers' research participation level that is used to generate appropriate and easily disseminated technology in the area. FREG members (52 male and 8 female) did technology evaluation by setting their selection criteria. The criteria were spike length, maturity date, plant height, head size, and tillering. The FREG members have been ranked for each selection criterion (Table 6).

After setting the rank of each criterion the FREG members gave a score for the treatment based on each selection criteria from one up to 5 scores and weighted the criteria to select the best technology. Based on the above-listed selection criteria FREG members have selected

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during the maturation phase, and they approved and confirmed wheat production by irrigation. Additionally, they examined the variations in the field and chose and observed the best-performing bread wheat varieties based on their performance in the field. Because of early maturing ability and yield performance Fentale-2 and Werer-2 varieties can produce under irrigation so, farmers preferred the technology. Farmers and extension workers were motivated by the demonstrated technology and awareness creation activities. Because of the high