# 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 diferent 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 fled under irrigation. The analysis of variance in both sets of experiments indicated that there was a highly signifcant diference (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 signifcant diference 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.

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The 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. e 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. erefore, 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.

## Da a

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Days to heading (days): e number of days was recorded from the date of emergency to the stage when the spikes of 50% of the plants are fully visible (exerted). Grain lling period (days): e grain lling 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.

**a a**

Plant height (cm): e 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. ousand kernels weight (gm): e weight of one thousand randomly on their interest and probability of success and failures of irrigation wheat technology adoption. ese host farmers were selected together with the district o ce of agriculture.

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Analysis of variance (ANOVA) was computed to test the presence of signi cant di erences among the genotypes for studied traits. e data were collected for each quantitative trait and would be subject to analysis of variance using R-studio version 4.2.2. Fishers protected least signi cant di erence (LSD) at 1% and 5% level of signi cance will be used for mean comparisons, whenever the Analysis of Variance (ANOVA) result showed a di erence among genotypes for traits. In the demonstrations, the collected data were analyzed by simple descriptive statistics like mean, minimum, maximum, and percentage, and also Partial budget analysis, a sensitivity analysis was done.

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e analysis of variance (ANOVA) showed that there was a highly signi cant (p<0.01) di erence among the varieties of most of the studied traits. e signi cant di erence among the bread wheat varieties for the traits indicates the presence of genetic variation among the varieties which is important for easily selection of varieties for improving both yield and quality traits. Similarly, reported that there is considerable genetic variability existing for quantitative and qualitative traits in bread wheat varieties.

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Days to heading were found to be highly signi cant (p≤0.01) among the tested verities for both trial sets. e mean of the heading days was found to be 57.83 days. Among the tested verities, the earliest heading days were observed on varieties Ardi and Deka (43.67 & 49.67 days), and the earliest maturity days were recorded from Ardi (80 days) and Kingbird (84 days) to heat tolerance and rain feed respectively. ese varieties were registered relatively earlier dates of heading and maturity as compared to the other varieties. is indicates these varieties are early maturing genotypes in which they mature 90 days a er sowing. e variations in uence directly grain yield which means the shortest days to maturity are forced to yield penalty and Vis versa. is help to plan our breeding program by grouping varieties that are early and late maturing. Reported that the physiological maturity of the wheat crop was delayed in the early sowing date but it depended upon the prevailing weather conditions and genetic composition of the variety. Late days to heading were recorded from variety Luci (70.67 days) and Lemu (64 days) the latest days to maturity were recorded from variety Lucy (98.67 days) and Lemu (97.33 days) for heat tolerance & rain feed respectively. According to the report made by. Changes in mean temperatures can shorten the time to maturity of a crop, thus reducing yield. is is due to the reason that rising temperatures will decrease the length of the grain- lling period of wheat and other small grains. Increases in temperature above 25 to 35ºC during grain lling of wheat will shorten the grain lling period and reduce wheat yields. When these temperature increases are extrapolated to the global scale a 5.4% decrease in wheat yield per 1ºC increase in temperature is expected (Table 3).

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e tested heat tolerance bread wheat varieties were signi cantly di ered (P<0.05) in their plant height and spike length and highly signi cant variation observed (p<0.01) for rain feed varieties. However, the tested varieties of both sets were highly signi cant (P<0.01) spikelet per spike and number of kernels per spike. Gambo (10.75 cm), Fentale-1 (10.13 cm), Amibara-1 (10.11), Ogolcho (11.17), Alidoro (11.79), and Adet-1 (10.08) bread wheat varieties registered higher spike length, plant height and number of spikelet per spike while Ardi, Werer-2, Deka, Kingbird, Wane varieties produced lower plant height (82.55, 80.46, 79.42, 79, 77.42cm), spike length (9.04, 8.88, 9.58, 9.25, ts 6(e)5(n)8(g)-3(tho )0.5((10.75 )0.5(cm), )]TJ0.207 Tw 0 -1.2 Ts 60.5((10.75

for biological yield in heat tolerance bread wheat varieties while non-signi cant variation from rain feed varieties. e mean value of biological yield for heat-tolerance tested wheat varieties is 13147.82kg/ha. e 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. is result indicated/con rmed 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 feed varieties.

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ere was a highly signi cant di erence (p≤0.001) among the tested varieties in both sets in grain yield (Tables 3 & 4). Grain yield was taken a er the harvest of wheat genotypes and measured at the standard moisture content (12.5) of wheat. e mean grain yield heat tolerance varieties were 5670.81kg ha-1 & 3953kg ha-1 in rain feed. 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 feed 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 feed 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 e ective tiller production, plant height, spikelet length, number of spikes per spike, number of normal kernels per spike, and thousand kernels weight. is 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 ( orets) per panicle, the percent (ripened) spikelet, and the thousand grain weight. Among all the yield attributes of wheat, panicle number per $m^2$ is highly correlated with grain yield and it is the most important factor that causes variation in grain yield. ey have also shown earlier times of heading and maturity periods. is con rmed the result of. at found early heading genotypes could perform better compared to latter heading cultivars where heat stress or high temperature occurred a er anthesis due to the reason that early heading cultivars have a longer post-heading period enabled them to have greater grain lling period and completed their grain lling earlier when the air temperature is lower which is more favorable by escaping the most severe e ects of heat stress compared to later heading genotypes (Table 4).

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ousand Kernels' weight showed a highly signi cant di erence (p≤0.001) among the tested varieties. e mean thousand Kernels weight was 38.81gm and ranged from 35.14gm to 42.09gm (Table 3). e 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 feed 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). ousand 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. ese 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 lling period. Flour industrialists attach special importance to thousand seed weight since there is a signi cant positive correlation between this trait and our yield.

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Correlation coe cients between the di erent pair of yield traits of the tested wheat varieties were calculated to nd out the relationship among the various yield traits studied as presented in below, (Figures 1& 2).

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

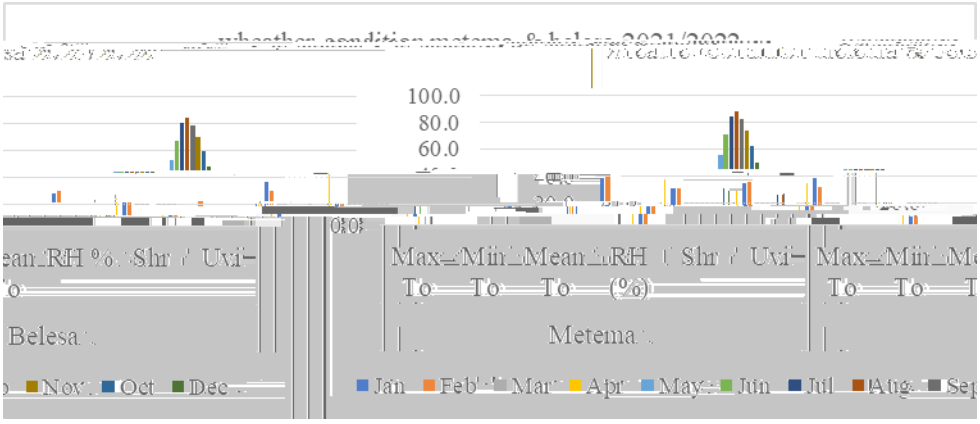

**Figure 1:** Graphical representation of weather conditions in 2020/2021 at Metema and Belesa districts.

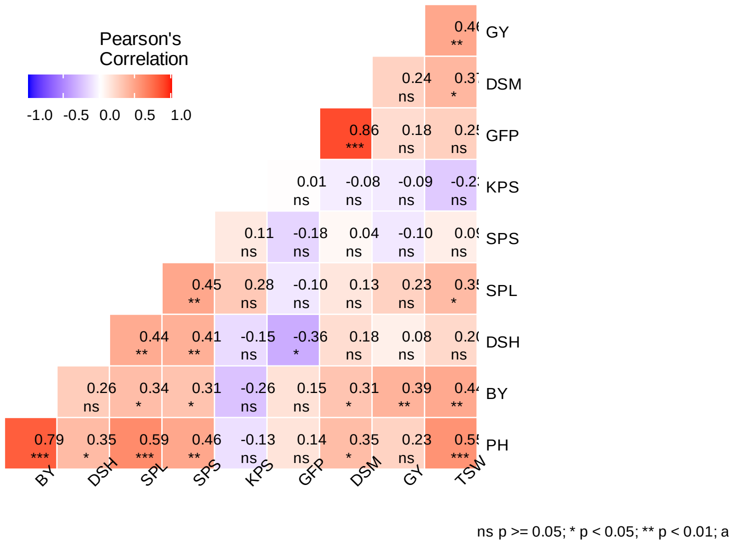


**Figure: 2** The correlation of traits among the tested bread wheat varieties under irrigation.

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.

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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).

This 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).

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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 spick 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

**Citation:** Azene Y, Yediemie S, Kasahun T(2023) Adaptation and Promotion of Improved Beard Wheat *Triticum aestivum* L Varieties Under Irrigation in North West Amhara Ethiopia. Adv Crop Sci Tech 11: 610.

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