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Research Article

Grain Yield and Yield Related Traits of Bread Wheat as Influenced by N and Seeding Rates and Their Interaction Effects in 2020 under Irrigation at Western and North of Oromia, Ethiopia

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Wheat is among the cultivated and important crops in Ethiopia because of its high value as a stable food that is mostly grown under rain-fed conditions. Even though the country has the potential to produce a sufficient amount of wheat grain under rain-fed and by using irrigation, the country still depends on importing wheat grain every year. Soil fertility depletion, inappropriate agronomic practices, erratic rainfall, and drought are among the constraints to the low yield of wheat crops in the country. In view of this, the field experiment was conducted during the off-season of 2020 in five districts, namely, Horo, Jimma Geneti, Jimma Arjo, Wayu Tuka, and Degem districts that are selected as representatives in terms of agricultural production and irrigation potential. The treatments consisted of five N fertilizer levels (0, 23, 46, 69, and 92 $kg \cdot ha^{-1}$) and three seeding rates (125, 150, and 175 $kg \cdot ha^{-1}$) of bread wheat, which constituted a total of 15 treatments. The experiment was laid out in a randomized complete block design with a factorial arrangement in three replications. The plot size was 3 m × 5 m. From the study, we observed that the grain yield and yield components of wheat were improved by optimizing nitrogen application and plant population. Maximum grain yield of 6.8, 8.9, 4.1, 4.8, and 2.5 $t \cdot ha^{-1}$ was recorded in response to the use of 92/125, 23/150, 23/150 and 175, 69/150, and 69/175 $kg \cdot ha^{-1}$ N/seed rate of wheat under irrigation condition in Horo, Jimma Geneti, Jimma Arjo, Wayu Tuka, and Degem districts, respectively. On the contrary, the lowest yield was observed from the unfertilized plot that was planted at 125 $kg \cdot ha^{-1}$ seed rate in all districts, except in Jimma Geneti, which was observed at 0/150 $kg \cdot ha^{-1}$ N/seed rate. The differences in yield between districts are mainly attributed to the variability in their soil-plant nutrient contents. Thus, N fertilizer and seed rates at 23/150, 69/150, 46/50, and 92/125 $kg \cdot ha^{-1}$ in Jimma Arjo and Jimma Geneti, Wayu Tuka, Degem, and Horo districts, respectively, gave maximum yield and net benefit with acceptable marginal rate of return, and it is economically feasible and the best rate to use by the end-users in bread wheat production under irrigation condition in the study area and agro-ecologies that are similar to the study area.

1. Introduction

The strong performance of the agricultural sector in Ethiopia is rising at an average annual rate of 5.8% over the last twenty years [1], and more than 85 percent of the national growth domestic product of the country is derived from the agricultural sector, which is a key factor in declined poverty from 71% in 1995 to 31% in 2015 [2]. Indeed, the country formulated the Agricultural Development-Led Industrialization policy and placed a strong strategy in accelerating the agricultural growth, achieving food security [3], and using major stable crops by complementary technologies [4–6].

In this regard, wheat stands out as a success story of the ambitious agricultural product development goals of the Ethiopian government to improve the food security status of millions of households [7–9]. It is also a major pillar for food security due to its high value as a staple food for about more than 85% population of the country [10, 11]. Ethiopia is the second-largest wheat producer in sub-Saharan Africa following South Africa solely under rain-fed conditions [12], which is planted during the main *meher* rainy season from June to August and harvested from October to January.

The data for the major production season 2020/2021 (M*eher*) indicated that wheat production reached 5.7 million tons grown by 4.746 million farmers and accounts for more than 1.8 million hectares (14.6%) of the country's total grain production [13]. It is widely grown in the mid and highland altitudes within the range of 1500 to 3000 meters above the sea level (m.a.s.l) [14], with suitable altitude ranges from 1900–2700 m.a.s.l. Its mean national and regional (Oromia region, which contributes 57.4% wheat production) yield is 3.0 and 3.3 t·ha^{-1} [13], respectively, which is far below the world average and even under the research yields of over 6 t·ha^{-1} [15]. The country is still a net importer of wheat [7, 10, 16] to meet the demand for food for the millions of population of the country. For instance, in the year 2019/20 season, the national wheat grain production and annual consumption in Ethiopia were 5 and 7 million tons, respectively. The two million tons of wheat grain deficit were satisfied by imports. This costed the country about 700 to 1,000,000 USD and exposed the national food security to varying global price shifts for grain. Soil fertility depletion, inappropriate agronomic practices such as low seed rate, dependence on the traditional farming system, erratic rainfall, and drought are found to be the key constraints that are affecting both the yield and industrial quality of the wheat crops in the country.

The government of Ethiopia has an ambitious plan for wheat self-sufficiency by 2023 by expanding wheat area/cycle using irrigation-based wheat production with full production packages [10, 17]. In this regard, promising achievements were obtained in different parts of the country. Our primary 2019 yield results showed that more than 4.0 t·ha^{-1} grain yield on average, even model farmers harvested more than 6 t·ha^{-1}, which is an increase in productivity by 1 and 2 more yield using the rain-fed blanket recommendation of 46 kg·ha^{-1} nitrogen fertilizer and seed rate of 150 kg·ha^{-1}. Thus, the irrigated wheat production technologies such as optimum fertilizer and seeding rates need to be investigated to unlock the yield potential and increase the yield of improved bread wheat varieties under irrigation. Furthermore, nitrogen (N) fertilizer management in the bread wheat production system is one of the main concerns which potentially hold back crop productivity due to the continued utilization of only N and P fertilizers as per the blanket recommendation [18, 19]. Nevertheless, N application beyond the optimum requirement of wheat could not increase yield and may lead to an elevated level of NO_3 in the soil and susceptibility to NO_3 loss by leaching [20, 21]. On the other hand, except for the EthioSIS map, so far there is no information/research finding on bread wheat varieties to the N fertilizers under irrigation conditions in the Oromia region as well as in Ethiopia [22].

The seed rate is another agronomic aspect that manipulates the yield of wheat. The smallholder farmers in Ethiopia, particularly in most parts of Oromia, mostly planted wheat in broadcast using 150–200 kg·ha^{-1} for many decades. Rafique et al. [23] stated that an increase in the seed rate over optimum may increase production costs without enhancement in yield. The seeding rate can also impact tillering, yield, and protein quality of the wheat crops. Jenneifer [24] reported that high wheat density reduced yield due to competition between plants. Similarly, Khan et al. [25] stated that if a higher seeding density is used, the plant density will be higher and there will be competition between plants for nutrients, sunlight, and water, resulting in low yield and poor quality. The less seed rate also results in low yield due to less plant population unit area^{-1}. However, Staggenborg et al. [26] point out that in varieties that produce fewer tillers, higher seeding rates compensated for the reduced tiller. Other authors Tigabu and Asfaw [27] explained that a higher grain yield (2.78 t·ha^{-1}) of wheat was achieved in plots planted with 100 kg·ha^{-1}. On the contrary, Alemayehu [28] reported that maximum grain yield was obtained at a 150 kg·ha^{-1} seed rate. Ram et al. [29] indicated that wheat seed sown at 160 kg·ha^{-1} gave a grain yield of 4.05 t·ha^{-1} compared to a yield of 3.83 t·ha^{-1} planted at 140 kg·ha^{-1} seed rates. Qaisar [30] compared different seeding rates and reported that higher grain yield was attained from the use of a 100 kg·ha^{-1} seed rate.

Thus, the future targets to meet the food demand of the ever-rising population of the country that can be attained either by increasing area or enhancing yield unit^{-1} by adopting appropriate production technology with the use of high-yielding cultivars, optimum seed rate, and adequate amount of fertilizers. Therefore, the study was conducted to develop the optimum amount of bread wheat seed and N fertilizer under irrigation conditions in Oromia, Ethiopia.

2. Materials and Methods

The field experiment was conducted during the off-season of 2020/21 in five districts, namely, Horo, Jimma Geneti, Jimma Arjo, Wayu Tuka, and Degem districts that are selected as representatives in terms of agricultural production specifically on their irrigation potential. The areas are located in subhumid parts of Oromia, Ethiopia that have variable climatic conditions with unimodal rainfall patterns, and maximum precipitation is received in July and August. The farming system of the areas is a mixed crop-livestock farming, and maize, tef, wheat, and coffee (in Wayu Tuka and Jimma, Arjo districts) are the major crops grown by the farmers in the areas. The soil type of an experimental area is sandy clay loam at Horo and clay loam at Jimma Geneti, Jimma Arjo, and Degem (Table 1).

The experiment was laid out in a randomized complete block design with a factorial arrangement in three replications. The plot size was 3 m × 5 m. The treatments consisted of five N fertilizer levels (0, 23, 46, 69, and 92 kg·ha^{-1}) and three seeding rates (125, 150, and 175 kg·ha^{-1}) of bread wheat, constituting a total of 15 treatments. The experimental fields were plowed four times at different intervals starting from the end of September and leveled manually before field planting. Recommended phosphorus (20 kg·ha^{-1}) in the form of NPSB was uniformly and equally

Table 1: Agro-ecologies of the districts.

District	Altitude (m)	Temperature (°c)	Rainfall (mm)	Soil type
Horo	1450–2844	11.8–22.7	787–1794.4	Clay loam 65%, sandy loam 10%, and others 25%
Jimma Geneti	2200–3400	15–25	1200–1800	Clay loam
Jimma Arjo	1200–2500	15–24	824–2616	Clay 58.2%, loamy 23%, sandy 11.6, and silt 4.8%
Wayu Tuka	1450–3300	12–32	1400–2400	Sandy 35%, clay loam 60%, and others 5%
Degem	1500–3541	8.7–20	900–1400	Nitosols, Vertisols, and Histosols

applied to all experimental units at the time of planting. On the other hand, N fertilizer in the form of urea was applied at different rates as constituted in the treatments which were applied 1/3rd at the time of planting, and the rest 2/3rd was applied at tillering growth stage of wheat. One bread wheat variety, Kakaba, was used as a test crop. The variety is well adapted to altitude areas of 1500–2200 m.a.s.l and it requires an annual rainfall of 500–800 mm with uniform distribution in its growing periods. Its yield potential ranges from 3.3–5.2 $t{\cdot}ha^{-1}$ in the research fields and 2.5–4.7 $t{\cdot}ha^{-1}$ in farmers' fields [31]. The trial was planted at an inter-row spacing of 30 cm with sowing by drilling methods. The spacing between ridges, plots, and blocks were 60 cm, 1 m, and 1.5 m, respectively. Other necessary cultural practices were applied to all plots uniformly as per recommendation for the variety. The wheat crop was harvested from the center rows by excluding the two border rows from each side. The net plot size for each plot was $2.1\,m \times 5\,m$ ($10.5\,m^2$). Plant height, spike length, number of effective tillers per plant, dry above-ground biomass, grain yield, thousand-grain weight, and other relevant agronomic traits were recorded at appropriate growth stages.

A preplanting and treatment application composite soil samples were collected at a depth of 0–30 cm following the standard method and analyzed for some selected physico-chemical properties of the soil at the soil laboratory of Bako and Fitche agricultural research center and Nekemte soil research center. Soil pH was measured by a digital pH meter in a 1 : 2.5 soil-to-solution ratio with H_2O. Soil particle size distribution was also determined using the hydrometer method [32]. Exchangeable bases of the soil were extracted with 1.0 molar ammonium acetate at pH 7, whereas Ca and Mg in the extract were determined using atomic absorption spectrophotometer [33]. Exchangeable acidity was assessed by extracting the soil samples with M KCl solution and titrating them with sodium hydroxide [34]. While the cation exchange capacity (CEC) of the soil was measured following the modified Kjeldahl method [35] and expressed as the CEC of the soil. On the other hand, organic carbon was determined by wet digestion methods as expressed by Walkley and Black [36]. The Kjeldahl procedure was used to determine total nitrogen (N) following the standard manual [37]. The available phosphorus, however, was measured following the Bray II procedure as described by [38].

Costs that vary among treatments were also assessed. The cost of wheat seed and grain, the cost of urea, and the cost of labor required for the application were estimated by assessing the current local market. Then, the price of seed (2826.25.00 ETB 100 kg^{-1}), the price of urea (1517.60 ETB 100 kg^{-1}), and the cost of daily labor (75.00 ETB per man per day) based on the current government scale in the study area were used to get the total cost that varied among the treatments. Other nonvaried costs were not included since all management practices were uniformly applied to each experimental plot. The harvested grain yields were adjusted down by 10% to reflect actual production environments. Gross revenue was calculated as adjusted grain yield multiplied by field price (2300.00 ETB 100 kg^{-1}) that farmers receive for the sale of the grain. The net benefit and the marginal rate of return were calculated as per the standard manual [39]. Finally, a combined analysis of variance was carried out using Gen Stat software, and Duncan's multiple range tests at $p < 0.05$ were used to compare treatment means [40].

3. Results and Discussion

3.1. Soil Physico-Chemical Properties of the Experimental Fields before Planting. Soil nutrient concentrations are estimated to be positively correlated for most nutrients as the concentration of a particular nutrient in the soil is greater [41]. Indeed, a soil test is indispensable for the further development of nutrient management. The preplanting and treatment application of physico-chemical properties of the experimental sites are presented in Table 2. The textural classes of the experimental sites were sandy clay loam and clay loam at Horo, Jimma Geneti, Jimma Arjo, and Degem districts, correspondingly. Although wheat is grown across a wide range of soil conditions, well-drained sandy clay loam and clay loam soils are ideal for wheat growing. On the other hand, the pH values of the experimental sites were 5.6, 6.1, 6.0, and 6.3 in Horo, Jimma Geneti, Jimma Arjo, Wayu Tuka, and Degem districts, respectively, which are found in moderately to slightly acid ranges as rating by Landon [42] interpreting the soil test. But wheat grows best when the Soil PH is between 6.0 and 7.0. Growing wheat at a PH below 6.0 often results in magnesium deficiency, slower mineralization of organic nitrogen, and reduced availability of phosphorus and increases the possibility of aluminum and manganese toxicity. While the available phosphorus (P) contents in the experimental sites varied between 6.8 and 10.9 ($mg{\cdot}kg^{-1}$) which is found to be in a deficient range (<10 $mg{\cdot}kg^{-1}$) at Horo, Jimma Arjo, and Degem but found in a medium range at Jimma Geneti (10.9 $mg{\cdot}kg^{-1}$) and Wayu Tuka (10.6 $mg{\cdot}kg^{-1}$),. As per ratings of soil test interoperating, an available P content in the soil below 5 $mg{\cdot}kg^{-1}$ values is found in a very low range. But available P between 5 and 9 $mg{\cdot}kg^{-1}$ is low, between 10 and 17 $mg{\cdot}kg^{-1}$ is medium, 18–25 $mg{\cdot}kg^{-1}$ is found in high, and soils containing greater than 25 $mg{\cdot}kg^{-1}$ values found in a very high P content

Table 2: Soil physico-chemical characterization of the study sites before planting in Horo, Jimma Geneti, Jimma Arjo, Wayu Tuka, and Degem districts in the 2020 season, Oromia, Ethiopia.

Soil parameters	Name of districts				
	Horo	Jimma Geneti	Jimma Arjo	Wayu Tuka	Degem
pH (1 : 2.5 H_2O)	5.6	6.1	6.0	6.0	6.3
Available P (ppm)	8.5	10.9	7.3	10.6	6.8
Total N (%)	0.2	0.3	0.5	0.2	0.1
Organic carbon (%)	4.5	3.4	2.2	1.6	3.4
Organic matter (%)	7.7	5.8	3.9	2.8	5.8
Ex. Acidity (cmol(+)·kg^{-1})	1.0	0.3	0.4	0.1	0.13
Ex. Ca (cmol(+)·kg^{-1})	4.2	5.2	4.3	17.5	35.4
Ex. Mg (cmol(+)·kg^{-1})	4.3	3.4	3.3	12.0	24.0
CEC (cmol(+)·kg^{-1})	34.6	38.0	30.4	36.6	33.1
Clay (%)	36.8	36.8	38.7		36
Silt (%)	23.3	22.4	29.2		22
Sand (%)	48.8	40.8	32.1		42
Texture	Sandy clay loam	Clay loam	Clay loam		Clay loam

Total N = total nitrogen, P = phosphorus, Ex = exchangeable, and CEC = cation exchangeable capacity.

[43–45]. Whereas, the total N contents of the experimental fields were ranging between 0.1 and 0.5% which is considered in the low to medium ranges. The total N levels between 0.1 and 0.2% values are found in the low range, while those below 0.1% are very low for tropical soils [42, 45]. Therefore, the study areas are low to medium in their total N status which could limit wheat production in the area and needs improvement with plant nutrients that contain N.

soil properties of the study areas also showed that the experimental sites were high in their cation exchange capacity (CEC) (30.4–38 coml(+)·kg^{-1}). The CEC value between 25 and 40 cmol(+)·kg^{-1} is taken as high in their CEC status, and it is ideal for wheat production (Hazelton and Murphy, 2007). The very high value of CEC is mainly due to the high clay content of the study areas (Table 2). Thus, as nutrient availability or uptake by plants depends on soil CEC, a CEC value above 10 cmol(+)·kg^{-1} soil is preferred for the plant growth. On the other hand, the organic carbon of the study sites varied between 1.6 and 4.5%. It was found to be in medium (0.5–7.5%) and optimal for wheat grown under irrigation. The exchangeable Ca and Mg content of the soil in the study sites ranged from 4.2 to 35.4 (cmol(+)·kg^{-1}), and 3.3 to 24.0 (cmol(+)·kg^{-1}), respectively (Table 2). The soil concentration of Ca can vary greatly and is generally related to soil pH. Soils with a pH of 6.0 or greater generally have sufficient Ca for the plant growth. According to the ratings suggested by Hazelton and Murphy [46] interpreting soil test results, the Ca contents of the experimental sites are found in low to very high ranges, whereas the Mg value is found in very high ranges. Hazelton and Murphy [46] also stated that the Ca content below 0.1 (cmol(+)·kg^{-1}) value is very low, between 2 and 5 (cmo l(+)·kg^{-1}) is low, 5–10 (cmol(+)·kg^{-1}) is moderate, 10–20 is high, and greater than 20 (cmol(+)·kg^{-1}) ranges are found in a very high range. While as per ratings of the soil test interpreting, the Mg content in the soil below 0.3 cmol(+)·kg^{-1} is found in very low range. But the values between 0.3 to 1.0 cmol(+)·kg^{-1} is found in low range. On the other hand, the Mg values between 1–3 cmol(+)·kg^{-1} found in moderate, values 3–8 in high, and more than 8 cmol(+)·kg^{-1} level is found in very high range. Therefore, the Mg contents of the experimental areas are ideal for wheat growing under irrigation condition, whereas in Horo and Jimma Arjo, the Ca contents in the soil is deficient and needs amendments. Generally, from the present study, we understand that the study areas of the soil content are optimal for the wheat growth except for a deficiency in the values of available total N and P. The nutrient deficiencies identified by the study could be because of either the inherently low availability of these nutrients in the soils or as a consequence of continued intensive cropping without applying fertilizers.

3.2. Analysis of Variance for Yield and Yield Traits of Bread Wheat as Influenced by Nitrogen and Seed Rates and Their Interaction Effects in 2020 at Western and North Oromia, Ethiopia. The result of a combined analysis of variance showed that the interaction of various levels of applied N fertilizer and seeding rates significantly ($p < 0.01$) affected grain yield, dry biomass, grain per spike, and number of effective tillers per plant over locations (Table 3). Thousand kernels weight (TKW) and Harvest Index (HI) were also significantly ($p < 0.05$) affected due to the use of the various levels of N fertilizer and seeding rates. On the contrary, the response of plant height and spike length to applied N and seed rate did not show significant variations between treatments used. On the other hand, the main effects of N application showed a highly significant variation to all parameters except for HI and thousand kernel weight (TKW) which was affected significantly at a $p < 0.05$ significance level. Furthermore, grain yield and dry biomass were significantly ($p < 0.01$) affected due to the various levels of seeding rates, but no significant differences were observed in TKW, grain per spike, spike length, and the number of effective tillers per plant between the used levels of seed rates. Moreover, the response of grain yield of wheat was considerably varied to the applied N and seed rate

Table 3: Analysis of variance of applied N and seeding rates in Jimma Arjo, Jimma Geneti, Wayu Tuka, Horo, and Degem districts in 2020 season under irrigation conditions.

		MS							
Source of variation	D.f.	GY	DB	TKW	GSK	HI	PH	SL	#Tiller
N	4	7.6**	29.9**	18.9*	181.8**	43.3*	205.3**	2.5**	1.1**
SD	2	5.0**	17.5**	8.0ns	1.3ns	33.8*	50.5*	0.5ns	0.25ns
Loc	4	242.7**	1208.5**	1841.2**	7247.7**	3652.2**	7148.7**	24.1**	216.1**
N * SD	8	0.96**	1.8**	6.97ns	23.8*	54.6**	14.2ns	0.58ns	0.76**
N * SD * Loc	32	0.41**	1.5**	11.2*	36.5**	19.8*	19.8ns	0.40ns	0.51**
Replication	2	0.32ns	0.2ns	13.2ns	0.09ns	80.2**	23.9ns	3.1*	0.79*
Residual	148	0.16	0.2	7.08	8.7	10.9	14.1	0.44	0.16
Total	224	—	—	—	—	—	—	—	—
CV (%)		8.3	4.6	5.8	6.9	6.3	4.3	7.6	9.6
LSD (5%)		0.29	0.32	1.92	2.13	2.39	2.71	0.48	0.29

*and ** = significant difference at 5% and 1% probability level, ns = nonsignificant difference, MS = mean square, d.f. = degree freedom = grain yield, DB = above ground dry biomass, TKW = thousand kernel weight, GSK = grain per spike, HI = harvest index, PH = plant height and SL = spike length, SD = seed rate, Loc = location, and N = nitrogen.

among the testing locations (districts) due to soil fertility differences between the districts as described in Table 2.

3.3. Mean Grain Yield and Dry Biomass of Bread Wheat. As shown in Table 4, the grain yield and dry biomass of wheat was considerably influenced by the use of different levels of N fertilizer and seeding rates at all tested locations. Tagesse et al. [47] reported that the mean grain yield and dry biomass of wheat were significantly affected by the application of N fertilizer and seed rates. The obtained grain yield and dry biomass ranged from 3.4 to 5.2 t·ha^{-1}, and 7.3–10.7 t·ha^{-1}, respectively. The highest mean grain yield (5.2 t·ha^{-1}) and dry biomass (10.7 t·ha^{-1}), however, was attained at the N level of 92 kg·ha^{-1} and 175 kg·ha^{-1} seeded. Statistically comparable yield (5.1 kg·ha^{-1}) performance was also recorded from the use of 23 kg N·ha^{-1} combined with 150 kg·ha^{-1} seed rates than other treatment combinations, which is statistically at par with 92 kg N·ha^{-1} which planted in seed rates of 175 kg·ha^{-1}.

The maximum grain yield of bread wheat was attained from the use of maximum N levels and seeding rates (Table 4). Different scholars reported similar results [48–50]. Mojiri and Arzani [51] point out that N fertilizer up to 150 kg·ha^{-1} increased the yield of wheat. On the contrary, Amare [8] points out that the 100 kg·ha^{-1} seed rate of bread wheat gave a higher yield in the Kombolcha district, South Wollo zone, Ethiopia. The grain yield of wheat increased significantly with the increased level of N and seed rate up to the application of 23 kg N·ha^{-1} and 150 kg·ha^{-1} seeding rates and then minimum increment after that (Table 4). This suggests that the extra N levels greater than 23 kg N·ha^{-1} had little influence on increasing yield. Similar findings were reported by Zemichael and Dechassa [52].

The lowest yield (3.4 kg·ha^{-1}) and dry biomass (7.3 t·ha^{-1}) were, however, attained from the plots receiving no N application that was planted in 125 kg·ha^{-1} seeding rate compared to other treatment combinations (Table 4). This might be attributed to deficiencies of N fertilizer which results in reduced production of photosynthates and lower plant population unit area^{-1}. Two authors, Zemichael and Dechassa [52], indicated that lack of N fertilizer affected grain development processes in wheat because of N deficiencies, which may have resulted in stomatal closing and prematuring of the wheat crop. In addition, some fertilizer nitrogen may be inadequately taken by the plant and some of it may have been lost through leaching, denitrification, or volatilization [21, 52, 53].

The maximum grain yield (5.2 t·ha^{-1}) produced, which was agronomically optimum in this experiment, was 42.3% higher than the national average yield (3.0 t·ha^{-1}) obtained during the rainy season using the blanket recommendation of 46 kg N·ha^{-1} and 150–200 kg·ha^{-1} seed rates of bread wheat crop. The probable reason for higher yields than during the rainy season might be largely attributed to the result of optimum plant density area^{-1} and N in delayed leaf senescence in grain filling time that sustains leaf photosynthesis activity and extended period of grain filling when moisture supply in the soil was not limited [54, 55]. This result reveals that farmers in the study areas are losing about 58% of wheat grain yield due to poor agronomic practices under the rain-fed production system, although the blanket recommended rate of fertilizer they apply on average to the crop seems adequate. The results are in line with the findings of Tsegay et al. [56] and Zemichael and Dechassa [52] who reported that uptake of N and P was enhanced in response to increasing the rates of the fertilizers in the presence of sufficient moisture in the soil.

3.4. Mean Grain Yield Performance of Bread Wheat across Districts. The grain yield of bread wheat response to applied N fertilizer and seed rates also significantly varied among the testing sites. To this, the highest yield (8.9 t·ha^{-1}) performance of bread wheat was obtained in the Jimma Geneti district when 23 kg N·ha^{-1} and 150 seeding rates were practiced (Table 5). The preplanting and treatment application soil test results showed that the experimental field in Jimma Geneti is better in its N soil contents than the other districts (Table 2), and because of this, the higher yield was

Table 4: The overall mean effects of N and N seeding rate on grain yield, dry biomass, and other yield traits of bread wheat over locations in the 2020 in western Oromia, Ethiopia.

N levels ($kg\cdot ha^{-1}$)	Seeding rates ($kg\cdot ha^{-1}$)	GY ($t\cdot ha^{-1}$)	DB ($t\cdot ha^{-1}$)	TKW (g)	Grain spike^{-1}	HI (%)	PH (cm)	SL (cm)	Tillers no. plant^{-1}
	125	3.4e	7.3	47.1	40.4	50.3	82.8	8.7	4.2
0	150	4.3d	9.0	46.8	39.4	54.1	83.1	8.5	3.9
	175	4.6cd	8.6	46.6	39.8	56.2	83.2	8.0	3.7
	125	4.5d	9.0	45.4	42.9	51.8	84.2	8.6	4.5
23	150	5.1ab	9.9	45.0	42.9	53.9	84.4	8.5	4.0
	175	5.1ab	10.4	45.1	46.2	51.6	88.2	8.8	4.1
	125	4.8bc	9.7	46.0	40.9	52.8	86.3	8.8	4.3
46	150	5.1ab	10.3	45.3	42.5	51.6	87.4	8.8	4.4
	175	5.0ab	10.3	45.8	40.2	52.3	87.8	8.7	4.1
	125	4.8bc	9.8	46.0	45.2	50.7	87.3	8.9	4.2
69	150	5.1ab	10.1	45.8	45.0	53.8	87.2	9.0	4.4
	175	5.1ab	10.3	45.4	44.2	49.4	88.8	8.9	4.5
	125	5.1ab	10.0	45.2	43.8	52.2	87.5	9.2	4.0
92	150	5.1ab	10.1	44.1	42.1	50.8	89.3	9.2	4.4
	175	5.2a	10.7	46.9	42.2	50.3	88.3	8.7	4.2
LSD (5%)		0.29	0.32	NS	2.13	2.39	NS	NS	0.29
CV (%)		8.3	4.6	5.8	6.9	6.3	4.3	7.6	9.6

Table 5: The mean effects of various levels of N and seeding rates on grain yield of bread wheat across districts in 2020/21 under irrigation in Oromia, Ethiopia.

Treatments		Grain yield ($t\cdot ha^{-1}$)					
N levels ($kg\cdot ha^{-1}$)	Seeding rates ($kg\cdot ha^{-1}$)	Horo	Jimma Geneti	Jimma Arjo	Wayu Tuka	Degem	Mean
	125	3.4	7.0	1.7	3.3	1.5	**3.4**
0	150	6.1	6.6	3.7	3.5	1.6	**4.3**
	175	6.2	6.8	4.0	4.1	1.9	**4.6**
	125	5.3	8.1	3.4	3.5	2.0	**4.5**
23	150	6.4	8.9	4.1	4.1	2.1	**5.1**
	175	6.2	8.8	4.1	4.1	2.2	**5.1**
	125	5.4	8.5	3.7	4.6	1.9	**4.8**
46	150	6.3	8.4	4.1	4.2	2.4	**5.1**
	175	5.8	8.4	3.8	4.6	2.3	**5.0**
	125	5.9	8.2	3.8	4.1	2.0	**4.8**
69	150	6.6	8.0	3.8	4.8	2.3	**5.1**
	175	6.4	8.4	3.6	4.5	2.5	**5.1**
	125	6.8	8.7	3.7	4.0	2.4	**5.1**
92	150	6.4	8.8	3.8	4.1	2.3	**5.1**
	175	6.4	8.8	4.0	4.6	2.4	**5.2**
Mean		**6.0**	**8.2**	**3.7**	**4.1**	**2.1**	**4.8**

Bold values are the mean grain yield across the districts.

recorded at the minimum N rates. In the Horo district, however, the maximum yield of 6.8 $t\cdot ha^{-1}$ was attained at 92 kg $N\cdot ha^{-1}$ and 125 seed rates. According to the ratings by Landon (1991), the experimental area of the soil is low in its N contents (Table 2), and, therefore, high doses of N application is needed to obtain a higher yield of bread wheat production using irrigation. While in the Wayu Tuka district, the higher grain yield (4.8 $t\cdot ha^{-1}$) was achieved from the treatment combinations of 69 kg $N\cdot ha^{-1}$ that were planted in 150 $kg\cdot ha^{-1}$ seeding rates. From the result of the pre-treatment application soil test, we observed that the experimental area of the soil is found in a low value in its N contents and needs sufficient amounts of N fertilizer application to obtain higher yields of bread wheat in irrigation conditions. In the same fashion, in the Jimma Arjo district, the higher grain yield of 4.0 $t\cdot ha^{-1}$ was recorded when 23 kg $N\cdot ha^{-1}$ was combined with 150 and 175 seed rates. From the result, we observed that the maximum yield was achieved from the lowest N rates (23 $kg\cdot ha^{-1}$). This might be due to the availability of some amounts of total N in the experimental site before treatment applications, and the pH values are also at optimum ranges for wheat production (Table 2). Whereas, in the Degem district, the maximum grain yield (2.5 $t\cdot ha^{-1}$) of bread wheat was obtained when 69 $kg\cdot N\cdot ha^{-1}$ and

Table 6: The effects of various levels of N and seeding rates on dry biomass, grain per spike, harvest index (HI), and number of effective tillers of bread wheat in Horo, Jimma Geneti, and Jimma Arjo districts in 2020/21 under irrigation in western and north of Oromia, Ethiopia.

Treatments		Horo				Jimma Geneti				Jimma Arjo			
N levels (kg·ha^{-1})	Seed rates (kg·ha^{-1})	DB (t·ha^{-1})	Grain spike^{-1}	HI (%)	Tillers no. plant^{-1}	DB (t·ha^{-1})	Grain spike^{-1}	HI (%)	Tillers no. plant^{-1}	DB (t·ha^{-1})	Grain spike^{-1}	HI (%)	Tillers no. plant^{-1}
	125	7.9	43.0	48.2	2.8	14.5	50.8	48.2	6.3	4.3	49.9	41.0	5.9
0	150	12.4	46.7	48.1	3.1	16.1	48.3	48.1	7.3	7.4	55.8	49.9	4.4
	175	10.6	41.1	52.3	3.3	14.2	54.9	52.3	6.3	8.1	50.1	49.4	4.3
	125	10.4	48.5	48.3	3.9	16.8	53.6	48.3	7.5	7.5	55.7	45.5	5.3
23	150	12.8	41.5	49.0	3.3	18.2	55.5	49.0	6.7	7.8	52.3	52.8	4.5
	175	12.5	48.9	48.4	3.2	18.1	56.9	48.4	6.7	8.4	55.0	48.5	4.5
	125	10.5	41.2	47.0	3.0	18.3	54.8	47.0	7.3	6.8	52.7	54.4	4.6
46	150	12.9	51.1	48.2	3.7	17.4	53.1	48.2	7.7	8.2	50.5	47.3	4.9
	175	11.6	41.9	47.1	3.2	18.1	57.8	47.1	7.5	7.4	50.5	50.7	4.5
	125	11.5	47.2	46.7	3.3	17.5	60.3	46.7	7.5	7.7	50.7	49.2	4.3
69	150	13.1	48.5	49.5	2.9	16.5	60.1	49.5	8.2	7.5	55.1	50.8	3.8
	175	12.5	48.4	47.2	3.2	17.6	57.7	47.2	7.8	7.8	52.5	46.3	4.8
	125	12.5	50.9	49.9	3.5	17.2	53.1	49.9	6.5	7.4	49.6	50.2	4.6
92	150	12.4	47.2	50.5	3.5	17.5	53.1	50.5	6.8	7.5	51.1	50.6	5.0
	175	12.7	44.7	46.9	3.3	18.7	55.2	46.9	7.8	8.4	55.4	48.7	4.6
Mean		**11.8**	**46.1**	**48.5**	**3.3**	**17.1**	**55.0**	**48.5**	**7.2**	**7.5**	**52.5**	**49.0**	**4.7**

Table 7: The effects of various levels of N and seeding rates on dry biomass, grain per spike, harvest index (HI), and number of effective tillers of bread wheat in Wayu Tuka and Degem districts in 2020/21 under irrigation in western and north of Oromia, Ethiopia.

Treatments		Wayu Tuka				Degem			
N levels (kg·ha^{-1})	Seed rates (kg·ha^{-1})	DB (t·ha^{-1})	Grain spike^{-1}	HI (%)	Tillers no. plant^{-1}	DB (t·ha^{-1})	Grain spike^{-1}	HI (%)	Tillers no. plant^{-1}
0	**125**	7.2	36.0	47.0	1.5	2.4	22.5	67.3	4.8
	150	7.0	22.3	51.5	1.3	2.2	24.0	73.1	4.1
	175	7.5	33.3	54.4	1.1	2.4	19.3	72.3	3.9
23	**125**	7.9	34.0	45.7	1.4	2.7	22.6	71.3	4.7
	150	8.0	38.7	45.9	1.0	2.9	26.7	72.7	4.4
	175	9.5	39.3	43.2	1.3	3.3	31.0	69.5	5.1
46	**125**	10.4	32.0	45.3	1.7	2.7	24.0	70.6	4.9
	150	9.3	35.3	45.6	1.7	3.7	22.3	69.0	4.2
	175	11.4	28.3	40.9	1.3	3.0	22.7	75.9	4.3
69	**125**	8.8	37.7	47.8	1.2	3.2	30.1	62.8	4.9
	150	10.2	32.7	47.7	1.3	3.2	28.5	71.6	5.9
	175	9.5	33.7	47.1	1.3	4.3	28.9	59.2	5.5
92	**125**	9.0	35.3	44.8	1.0	3.6	29.7	66.0	4.4
	150	9.1	37.3	45.1	1.1	4.0	21.6	57.5	5.5
	175	10.2	33.0	45.4	1.1	3.8	22.6	63.6	4.3
Mean		**9.0**	**33.9**	**46.5**	**1.3**	**3.2**	**25.1**	**68.2**	**4.7**

Bold values are the mean for different parameters across the districts.

175 kg·ha^{-1} seed rate of bread wheat were used. The soil N contents of the experimental site in the Degem district are found in a very low range in its total N and available P, and, therefore, the maximum yield of bread wheat is observed from the higher N dose application. The minimum grain yield was, however, observed from the experimental plots unfertilized to N that were planted at 125 kg·ha^{-1}seed rates in all districts, except in Jimma Geneti; the minimum yield observed that no N fertilizer application was planted in 150 kg·ha^{-1} seed rate. This minimum yield might be due to N fertilizer deficiencies and lower plant population unit area^{-1}.

The yield differences among the districts that planted similar bread wheat varieties and treatments might be due to the variabilities in soil fertility status (as described in Table 2) or the different levels of land management history of the testing areas for crop production. The present study is in consistent with the findings of Belete et al. [57] who reported that variations in grain yield of wheat varieties were observed among testing sites and years. In addition, production history and a wide range of management practices at each farm field subsequently affect treatment response of on-farm research, and each farmer managed his farms in his way, such as applying either preplant or top-dress N fertilizer rates could be contributed to a great extent in yield variations of crops with similar crop variety and plant nutrient application [58–61]. Moreover, heterogeneity in soil fertility in smallholder farmers is caused by both inherent soil-landscape and human-induced variation across farms differing in resources and practices [62].

3.5. Crop Growth and Yield Components of Bread Wheat. The use of various levels of nitrogen fertilizer and seed rates also significantly affected the crop growth and yield traits of bread wheat across testing sites, but no significant variation was observed in plant height, spike length, and TKW between applied treatments in irrigated bread wheat (Table 3). The higher grain per spike (46.2) and HI (56.2%) were recorded when 23/175 and 0/175 kg·ha^{-1} N/seed rates were used, respectively (Table 4). Abdulkerim et al. [63] stated that seeding rates up to 150 kg·ha^{-1} produced a higher grain per spike. However, the present result is in contrast with Valério et al. [64] who point out that the wheat genotypes did not affect the number of grains per ear attained in different seeding densities. While the maximum number of productive tillers (4.5) per plant was observed at 23/125 and 69/175 kg·ha^{-1} N/seed rates practiced for bread wheat under irrigation conditions. This showed crop growth parameters and yield components of bread wheat contributed to grain yield directly or indirectly. Amare [8] stated that the number of effective tillers is the most important because of the final economic yield of the cereal crops. The current result is in agreement with Adinew [28] and Amare [8] who found that maximum productive tiller was recorded from minimum seed rate and vice versa under rain-fed conditions. On the other hand, Iqbal et al. [65] reported that maximum productive tillers were obtained at 200 kg ha^{-1} seed rates than at lower seeding rates under rain-fed conditions.

In addition, the yield components of bread wheat response to application of N and seed rates significantly varied between the testing locations. As indicated in Tables 6 and 7, the highest mean value for dry biomass (18.3 t·ha^{-1}), grain spike^{-1} (60.3), and effective number of tillers^{-1} (8.2) were attained in Jimma Geneti district when 46/125, 69/125, and 69/150 kg·ha^{-1} N/seeding rates were used, respectively (Table 6). This might be due to the fertility status of the experimental field in Jimma Geneti which is better in its total N, available P, and CEC soil contents than the other districts (Table 2). While the highest harvest index (54.4%) was recorded from the use of 175 kg·ha^{-1} seed rates that received no

Table 8: The effects of N fertilizer application and seed rate on the economic profitability of bread wheat production at Jimma Arjo and Jimma Geneti districts during 2020 under irrigation condition.

Trt N/Sd	Gy	Adj. Gy	TC	GB	NB	DA	MRR
Jimma Arjo district							
0/125	1.7	1.5	6390.3	35190.0	28799.7		
23/125	3.4	3.1	9866.6	70380.0	60513.4		912.3
0/150	3.7	3.3	10324.4	76590.0	66265.6		1256.6
46/125	3.7	3.3	11102.9	76590.0	65487.1	D	
0/175	4.0	3.6	11538.4	82800.0	71261.6		411.5
23/150	4.1	3.7	11720.7	84870.0	73149.3		1035.9
92/125	3.7	3.3	11912.6	76590.0	64677.4	D	
69/125	3.8	3.4	12019.2	78660.0	66640.8		
23/175	4.1	3.7	12454.7	84870.0	72415.3		
46/150	4.1	3.7	12477.0	84870.0	72393.0	D	
46/175	3.8	3.4	12731.0	78660.0	65929.0	D	
69/150	3.8	3.4	12753.3	78660.0	65906.7		
92/150	3.8	3.4	12806.6	78660.0	65853.4	D	
69/175	3.6	3.2	13167.3	74520.0	61352.7		
92/175	4.0	3.6	13860.7	82800.0	68939.3		
Jimma Geneti district							
0/125	7.0	6.3	14870.3	144900.0	130029.7		
0/150	6.6	5.9	14964.4	136620.0	121655.6	D	
0/175	6.8	6.1	16018.4	140760.0	124741.6	D	
23/125	8.1	7.3	17386.6	167670.0	150283.4		804.90
46/125	8.9	7.7	18782.9	175950.0	157167.1		493.0
69/125	8.8	7.4	19059.2	169740.0	150680.8	D	
46/150	8.5	7.6	19357.0	173880.0	154523.0		
23/150	8.4	8.0	19400.7	184230.0	164829.3		1240.3
69/150	8.4	7.2	19473.3	165600.0	146126.7	D	
92/125	8.2	7.8	19912.6	180090.0	160177.4		
23/175	8.0	7.9	19974.7	182160.0	162185.3		
46/175	8.4	7.6	20091.0	173880.0	153789.0	D	
92/150	8.7	7.9	20806.6	182160.0	161353.4		
69/175	8.8	7.6	20847.3	173880.0	153032.7	D	
92/175	8.8	7.9	21540.7	182160.0	160619.3		

N = nitrogen fertilizer levels, Sd = seed rate of bread wheat, Gy = average grain yield of wheat ($t{\cdot}ha^{-1}$), Adj.Gy = adjusted yield ($t{\cdot}ha^{-1}$), TC = total cost that varied among treatments ($ETB{\cdot}ha^{-1}$), GB = gross benefit ($ETB{\cdot}ha^{-1}$), NB = net benefit ($ETB{\cdot}ha^{-1}$), DA = dominance analysis, MRR = marginal rate of return (%), *D* = dominated, and 1 USD = 43.36 ETB.

Table 9: The effects of N fertilizer application and seed rate on the economic profitability of bread wheat production at Horo and Wayu Tuka districts during 2020 under irrigation condition.

Trt N/Sd	Gy	Adj. Gy	TC	GB	NB	DA	MRR
Horo district							
0/125	3.4	3.1	9110.3	70380.0	61269.7		
23/125	5.3	4.8	12906.6	109710.0	96803.4		936.0
46/125	5.4	4.9	13822.9	111780.0	97957.1		125.9
0/150	6.1	5.5	14164.4	126270.0	112105.6		4143.5
0/175	6.2	5.6	15058.4	128340.0	113281.6		131.5
69/125	5.9	5.3	15379.2	122130.0	106750.8	DA	
23/150	6.4	5.8	15400.7	132480.0	117079.3		1109.7
23/175	6.2	5.6	15814.7	128340.0	112525.3	DA	
46/175	5.8	5.2	15931.0	120060.0	104129.0	DA	
46/150	6.3	5.7	15997.0	130410.0	114413.0	DA	
92/125	6.8	6.1	16872.6	140760.0	123887.4		462.5
92/150	6.4	5.8	16966.6	132480.0	115513.4	DA	
69/150	6.6	5.9	17233.3	136620.0	119386.7	DA	
69/175	6.4	5.8	17647.3	132480.0	114832.7	DA	
92/175	6.4	5.8	17700.7	132480.0	114779.3	DA	
Wayu Tuka district							
0/125	3.3	3.0	8950.3	68310.0	59359.7		
0/150	3.5	3.2	10004.4	72450.0	62445.6		292.8
23/125	3.5	3.2	10026.6	72450.0	62423.4	D	
0/175	4.1	3.7	11698.4	84870.0	73171.6		633.2
23/150	4.1	3.7	11720.7	84870.0	73149.3	D	
92/125	4.0	3.6	12392.6	82800.0	70407.4	D	
23/175	4.1	3.7	12454.7	84870.0	72415.3		
69/125	4.1	3.7	12499.2	84870.0	72370.8	D	
46/125	4.6	4.1	12542.9	95220.0	82677.1		1125.6
46/150	4.2	3.8	12637.0	86940.0	74303.0	D	
92/150	4.1	3.7	13286.6	84870.0	71583.4	D	
46/175	4.6	4.1	14011.0	95220.0	81209.0		
69/150	4.8	4.3	14353.3	99360.0	85006.7		128.7
69/175	4.5	4.1	14607.3	93150.0	78542.7	D	
92/175	4.6	4.1	14820.7	95220.0	80399.3		

N = nitrogen fertilizer levels, Sd = seed rate of bread wheat, Gy = average grain yield of wheat ($t{\cdot}ha^{-1}$), Adj.Gy = adjusted yield ($t{\cdot}ha^{-1}$), TC = total cost that varied among treatments ($ETB{\cdot}ha^{-1}$), GB = gross benefit ($ETB{\cdot}ha^{-1}$), NB = net benefit ($ETB{\cdot}ha^{-1}$), DA = dominance analysis, MRR = marginal rate of return (%), *D* = dominated, and 1 USD = 43.36 ETB.

fertilization plots. In the Horo district, however, the maximum dry biomass ($13.1\,t{\cdot}ha^{-1}$), grain $spike^{-1}$ (51.1), harvest index (52.3%), and number effective $tillers^{-1}$ (3.9) were obtained at 69/150, 46/150, 0/175, and $46/125\,kg{\cdot}ha^{-1}$ N/seed rates was used, respectively (Table 6). On the other hand, in Jimma Arjo, higher dry biomass ($8.4\,t{\cdot}ha^{-1}$), grain $spike^{-1}$ (55.8), harvest index (54.4%), and number effective $tillers^{-1}$ (5.9) were achieved from the use of 23/175, 0/150, 46/125, and $0/125\,kg{\cdot}ha^{-1}$ N/seeding rates, respectively. In Wayu Tuka and Degem, however, the highest dry biomass of $11.4\,t{\cdot}ha^{-1}$, and $4.3\,t{\cdot}ha^{-1}$ was attained when 46 and $69\,kg{\cdot}N{\cdot}ha^{-1}$ was applied, respectively, that was planted in 175 kg seed rates (Table 7). Whereas, maximum number of grains $spike^{-1}$ (39.3 and 31.0) were recorded from the application of $23\,kg{\cdot}N{\cdot}ha^{-1}$ that was sown in $175\,kg{\cdot}ha^{-1}$ seed rates of bread wheat. The differences in yield components among the districts that used same bread wheat varieties and treatments might be due to the variabilities in soil fertility status or the different levels of land management history of the testing areas for crop production as described in Table 2.

3.6. Economic Feasibility of Nitrogen Fertilizer and Seed Rate on Bread Wheat Production under Irrigation Conditions in Oromia, Ethiopia. The partial budget analysis for means of treatment was also assessed. As indicated in Tables 8–10, the response of grain yield of bread wheat under irrigation to the applied treatments varied among the districts (Tables 3 and 5). Therefore, a separate economic analysis for each district was done since the variability in locations in their soil nutrient concentrations considerably affected the response of the treatments used on grain yield. Thus, in Jimma Arjo and Jimma Geneti districts, the highest net benefit ETB 73,149.3, and $164{,}829.3\,ha^{-1}$ with an acceptable marginal rate of return (MRR) (1035.9% and 1240.3%), respectively, was attained when $23\,kg{\cdot}N{\cdot}ha^{-1}$ that was planted in the $150\,kg{\cdot}ha^{-1}$ seed rate was

Table 10: The effects of N fertilizer application and seed rate on the economic profitability of bread wheat production at Degem district during 2020 under irrigation condition.

Trt N/Sd	Gy	Adj. Gy	TC	GB	NB	DA	MRR (%)
0/125	1.5	1.4	6070.3	31050.0	24979.7		
0/150	1.6	1.4	6964.4	33120.0	26155.6		131.5
23/125	2	1.8	7626.6	41400.0	33773.4		1150.3
0/175	1.9	1.7	8178.4	39330.0	31151.6	D	
46/125	1.9	1.7	8222.9	39330.0	31107.1	D	
23/150	2.1	1.9	8520.7	43470.0	34949.3		131.5
69/125	2	1.8	9139.2	41400.0	32260.8	D	
23/175	2.2	2.0	9414.7	45540.0	36125.3		131.5
46/150	2.4	2.2	9757.0	49680.0	39923.0		1109.7
92/125	2.4	2.2	9832.6	49680.0	39847.4	D	
46/175	2.3	2.1	10331.0	47610.0	37279.0	D	
69/150	2.3	2.1	10353.3	47610.0	37256.7	D	
92/150	2.3	2.1	10406.6	47610.0	37203.4	D	
92/175	2.4	2.2	11300.7	49680.0	38379.3		
69/175	2.5	2.3	11407.3	51750.0	40342.7		25.4

used (Table 8). Hence, the N level of 23 kg·ha^{-1} that was sown in the 150 kg·ha^{-1} seed rate is economically feasible for wheat production under irrigation in Jimma Arjo and Jimma Geneti districts, Western Oromia. In the Wayu Tuka district, however, the higher net benefit of ETB 85,006.70 ha^{-1} with an acceptable MRR (128.7%) was recorded at N levels of 69 kg·N·ha^{-1} that was planted in 150 kg·ha^{-1} seed rates (Table 9), and it is an economically viable application rate for bread wheat production under irrigation condition in Wayu Tuka district, East Wollega zone, Ethiopia. While in the Horo district, the maximum net benefit of ETB 12, 3887.40 ha^{-1} followed by ETB 117079.30 ha^{-1} with acceptable MRR (462.5%) was obtained from the use of 92 kg·N·ha^{-1} with 125 kg·ha^{-1} seed rate, and 23/150 kg·ha^{-1} N/seed rate of bread wheat, respectively (Table 9). Hence, N levels of 92 kg·ha^{-1} planted in 125 kg·ha^{-1} seed rates are economically optimum rates for bread wheat produced under irrigation in Horo district, Horo Guduru Wollega zone, Ethiopia. On the other hand, in the Degem district, 69 kg·N·ha^{-1} that was sown in the 175 kg·ha^{-1} seed rate was given the highest net benefit (ETB 40342.7 ha^{-1}) (Table 10). However, the acceptable MRR (1109.7%) with net benefit ETB 39923.0 ha^{-1}) was achieved when 46 kg·ha^{-1} N levels and 150 kg·ha^{-1} seed rate were practiced. Thus, 46 kg·N·ha^{-1} which was sown at the 150 kg·ha^{-1} seed rate is the best rate and economically feasible for irrigated bread wheat production in Degem district, North Shew zone, Oromia, Ethiopia.

4. Conclusion

Despite the huge yield potential, the existing production and productivity of bread wheat in Ethiopia is very low, and the country still depends on importing a huge amount of wheat grain every year to satisfy the demand of the country's population for food. Soil fertility depletion, inappropriate agronomic practices, erratic rainfall, and drought are the foremost constraints that are contributed to low yield and affect the quality of the wheat crops in the country. From the present study, we observed that the grain yield and yield components of bread wheat that were planted under irrigation were highly improved through optimizing nitrogen application and plant population. Maximum grain yield of 6.8, 8.9, 4.1, 4.8, and 2.5 t·ha^{-1} was attained in response to the use of 92/125, 23/150, 23/150 and 175, 69/150, and 69/175 kg·ha^{-1} N/seed rate of wheat under irrigation condition in Horo, Jimma Geneti, Jimma Arjo, Wayu Tuka, and Degem districts, correspondingly. On the contrary, the lowest yield was obtained from the unfertilized plots that were planted at a 125 kg·ha^{-1} seed rate in all districts, except in Jimma Geneti, which was observed from the plots with no fertilization with N that was sown at 150 kg·ha^{-1} seed rate of bread wheat. Based on the economic analysis, the maximum net benefit (ETB 73149.3 and 85006.7) and the acceptable marginal rate of return, 1035.9% and 128.7%, were attained from the application of 23 kg·N·ha^{-1} that was planted in 150 kg ha^{-1} seed rate in Jimma Arjo and Jimma Ganati districts, respectively, and, it is, therefore, economically feasible for irrigated bread wheat production in the study area. While in Wayu Tuka and Degem districts, the higher net benefit of ETB 85006.7 ha^{-1} and ETB 39923.0 ha^{-1} with an acceptable MRR (128.7%, and 1109.7%), respectively, was obtained when 69/150 and 46/150 kg·ha^{-1} N/seed rat were used. In the Horo district, however, the highest net benefit (ETB 123887.4 ha^{-1}) and acceptable MRR (462.5%) were achieved from N levels of 92 kg·ha^{-1} that was sown in the 125 kg·ha^{-1} seed rate of bread wheat production and economically viable to use in the area under irrigation condition. In conclusion, N fertilizer application and seed rate at 23/150, 69/150, 46/150, and 92/125 kg·ha^{-1} in Jimma Arjo and Jimma Geneti, Wayu Tuka, Degem, and Horo districts, respectively, gave maximum yield and net benefit with acceptable marginal rate of return, and it is therefore, economically feasible and the best rate to use by the end-users in bread wheat production under irrigation condition in the study area and agro-ecologies that are similar to the study area. Further research on a wide range of wheat growing in the country is enviable to obtain a holistic view of wheat production.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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