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Weeding Intensity and Plant Population Affect Yield and Yield Components of Food Barley (Hordeum Vulgare L.)

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Abstract

The most important crop in Jimma Geneti District, as well as Ethiopia, is food barley (Hordeum vulgare L.). However, because of poor agronomic techniques such as incorrect seed rates, weed problems, and other factors, its production is extremely low. Farmers in the Jimma Geneti district of Western Ethiopia have been using the earliest seed rate recommendation for their local area and have been producing with no regard for weeding, which has limited the productivity of food barley; the purpose of this study was to identify the optimum plant population required to increase production and productivity of food barley around the study area, as well as to identify an appropriate frequency of weeding in the study area in 2020 cropping season. The first factor was seed rate at four levels (115,125,135 and 145) kg ha^{-1}, and the second factor was weeding frequency at three levels (FP = Farmer's Practice, 1W = one weeding thirty days after the emergency; 2W = second weeding, twenty-five days after the first weeding) were utilized. The study found that the main effect and interaction effect of weeding frequency and seed rate had a significant ($P < 0.01$) impact on effective tiller number, plant height, spike length, biomass weight, grain yield, straw yield, harvest index, and 1000 kernel weight. Days to 90% physiological maturity and number of kernels per spike were both significantly ($P < 0.01$) affected by the main effects of weeding frequency and seed rate, whereas the interaction effect of weeding frequency and seed rate affected both considerably ($P < 0.05$). The primary effects of weeding frequency and seed rate were significantly ($P < 0.01$) affected days to 50% heading and weed relative density; however, their interaction effect of weeding frequency and seed rate was not significant. The highest grain yield 4750 Kg per hectare was with 145 kg seed rates and a 2nd cycle weeding following the 1st weeding. Guizotia scabra, the most prominent weed species coexisting with food barley, had the highest relative density of 20.89%. According to the present output and gross net benefit budget analysis, the highest net benefit 51015 ETB was obtained from 145 kg ha^{-1} seed rate with two times weeding following the first weeding, with grain yield increments of 61.41% over farmers practice. As a result, because this experiment was conducted at a single location for a single season, it must be repeated at other locations throughout the season to achieve a definitive conclusion.

Introduction

Hordeum vulgare L. is a monocot, herbaceous, one-year grass belonging to the family Poaceae, subfamily Pooideae, and tribe Triticeae [1]. Barley is one of the most important cereal crops grown around the world, and it is thought to have originated from the wild progenitor Hordeum spontaneum in the Fertile Crescent region of the Near East [2]. It ranks fourth in terms of production area behind wheat, maize, and rice [3, 4].

Barley production in the world is expected to be around 141.7 million tons [4]. And the European Union produces the most barley, with an estimated production of 20.5 million tons, followed by Russian federations with an estimated production of about 8 million tons, whereas barley production in Canada, the United States, and Argentina is estimated to be 7.3, 3.1, and 2.8 million tons, respectively [4].

Morocco, Ethiopia, Algeria, Tunisia, and South Africa were the top five African countries For the year 2016, the top five largest barley growers produced an estimated total of 2.1 million tonnes,1.85 million tons, 1.3 million tons, 0.5 million tons, and 0.307 million tons, respectively. More than half of the world's barley is grown in underdeveloped countries [5]. After teff, maize, sorghum, and wheat, Ethiopia is the only country in tropical Africa where barley is a major crop, ranking fifth in both area under cultivation and production [6], but third in yield per unit area [7].

Ethiopia is the world's 21st largest barley grower, accounting for 1.2%of global production, and Africa's second largest barley producer, after Morocco, and Algeria, accounting for nearly 25% of the continent's total barley production [8]. Furthermore, according to [9], scarcely is a reliable source of food in Ethiopia's highlands because it is grown during the major and short rainy seasons, as well as under residual moisture [10]. In most regions of Ethiopia, the major cropping season runs from June to September in the south western and central parts of the country [11]. Barley is an important grain crop in Ethiopia's highlands, where it is produced in a variety of ecologies from 1800 to 3400 meters above sea level under varied production systems with temperatures ranging from 15–20°C and annual rainfall ranging from 500 to 1200 mm. It thrives on silt to clay loam soil that is rich and well-drained [12].

In Ethiopia, barley production is concentrated in the Oromia National Regional State, which covers 454,662.78 hectares and produces roughly 1.09 million tons per year [13]. According to Ethiopia's Central Statistics Authority's 2014/2015 forecasts, of the 12.6 million hectares under grain crop cultivation, 80.78 percent was under cereals, which contributed 87.36 percent of grain production, and barley took up about 8% and 7% of the grain crop area and production, respectively [14]. Between 2003/04 and 2013/14, there was a significant increase in the number of The number of smallholders farming barley climbed from 3.5 million to 4.5 million between 2003/04 and 2013/14, yields increased from 1.17 to 1.87 tons per hectare, and total production increased from 1.0 million tons in 2005 to around 1.9 million tons in 2014 [15].

According to the [16], barley was grown by 3,714,340 households on 811,782.08 hectares of land, yielding 1767518.45 tons of grain, accounting for 5.63 percent of total grain production in Ethiopia during the 2018/19 meher cropping season. However, in Oromia, around 1,293,225 households produce approximately 932507.64 tons barley on an area of 386569.22 hectares, with a land productivity per hectare of 2.412. Similarly, according to USDA and GAIN [17], barley is grown on 1,205,000 hectares of land in Ethiopia, yielding roughly 2300,000 metric tons of grain, accounting for 5.63 percent of total grain production. In the 2019/20 meher cropping season, it accounted for 5.63 percent of total grain production in the country. However, barley productivity in producing fields has remained poor, at 1.96 t ha-1, compared to a global average of 2.95 t ha-1 [18; [19]. This is primarily due to the influence of several biotic and abiotic stresses factors, such as poor crop management practices, the use of low yielding cultivars, weeds, insects, and diseases, and the inherently low yield potential of the prevalent local varieties, which have contributed to this low productivity [20].

Despite the fact that barley occupies a significant amount of Ethiopia's cropland (10%) indicating low, [21]. This could be due to weed competition [22], which estimates that unchecked weed growth throughout the crop growth reduces yield by 42 percent during the meher (main) season [23].

Ethiopia covers 7.56 percent of the land under grain crop cultivation based on area of output yield per unit area [18]. On experimental plots, the potential yield reaches 6t/ha [21], indicating a productivity gap of roughly 4tones/ha. Filling this void would place Ethiopia among the world's top barley producers.

One of the most crucial aspects of crop production is seeding pace. A higher grain yield with better quality necessitates the use of the proper seeding [24]; [25]. An increase in seed rate above the optimum level may merely raise production costs while yields remain unchanged [26]. Furthermore, seed rate influences crop vigor and, eventually, yield [27]. Proper seeding supports nutrient availability, proper sun light penetration for

photosynthesis, a healthy soil environment for soil nutrient uptake, and efficient water use. Includes everything else required for crop vigor, resulting in increased crop production and productivity [28].

The critical period of weed control (CPWC) weeding frequency is a phase in the crop growth cycle when weeds must be controlled to avoid yield losses [29]. Variety Seem [30], climate, weed density, weed species, and crop planting date all influence the commencement and end of the crucial period [30]. In agriculture, weeds constitute a constant hindrance to agricultural productivity. And they're plants that compete for nutrients, space, and light, which can have a lot of negative consequences by lowering crop quality and quantity if weed populations aren't controlled [32]; [33]. Weeds can also raise the risk of pests in the crop since they act as a food source. Weeds can also raise the danger of pests in the crop by acting as hosts for insects and illnesses during times when there is no crop present [34]. Weeds have been identified as the leading cause of loss, accounting for 36% of all losses [35]. Poor weed control in cereals can result in significant yield losses, makes harvesting laborious, and is visually unappealing; in addition, poor control in one season can lead to difficulties with increased weed populations in succeeding crops [36].

The yearly average national yield of the crop in Ethiopia is just 1200 kg ha^{-1} [16]. The low national average yield, which is much below the world average, could be partly ascribed to poor weed control, which leads in intense weed competition. Weeds that emerge beyond the critical period have a lower competitive effect, but they can obstruct harvesting and serve as a subsequent source of field infection [23]. Depending on the location and type of weed, yield increases from weed control [37]. Weeds are a significant limitation in agricultural production systems because they act at the same tropic level as the crop, capturing a portion of the available resources required for plant growth [34]; [37].

Weed control has been identified as one of the most significant practices in crop production, as it ensures maximum yield and high quality agricultural produce [38]. Weeds are removed from within and around crops as part of current agricultural procedures [39]. In addition to weed control, good agronomic practices such as proper seeding are important. A strong agronomic practice like the right sowing rate is highly crucial to enhance crop yields, in addition to weeding management.

Reduced seed rates may result in more tillers and spikes per plant, as well as more spikelets per spike, but they often result in lower grain yields per hectare [40]. When seed rates are high, there is more competition, shorter spike lengths, and fewer grains per spike, which increases weed population. When seed rates are low, there is less competition, shorter spike lengths, and fewer grains per spike [41].

However, according to JGWANRO's annual report for 2020, 3465 hectares of land were cultivated by 4892 households, yielding 7276500 kg. Productivity is well below the national average output of 2.1 tons per hectare and far below the 4.75 tons obtained from the research field. In addition, weed infestation is the key bottleneck in Charo Keble's food barley crop output. Hailu [42] found similar results in Ethiopia, particularly during the rainy season.

To maximize the potential of available natural and environmental resources, optimal agronomic methods such as planting pattern, weeding frequency, and weed management elements are critical [43]. This showed that one of the essential agronomic managements to improve food barley production and productivity is to perform research and determine the weeding frequency and appropriate seed rate in the given growing region.

Farmers in the research area are aware of the weed problem in their fields, yet they frequently are unable to manage with weed infestation during the peak-season of agricultural activity. This could be due to a lack of awareness. As a result, most of their fields are weeded late (rarely) or not at all, and they are unaware of weeding frequencies. Ineffective weed management is a severe barrier to arable cropping profitability, causing the largest potential losses (36%) of all crop pests [44]; [45]. Farmers in this area rely heavily on the recommended seed rate (125 kg ha-1) determined by agricultural research as well as local sowing rates. Even the national seed rate recommendation was made more than ten years ago. There may have been changes in the production environment, soil fertility, soil moisture, and so on since this time. As a result, it requires a new or current recommendation result. As a result, in this particular study area, information on optimum seed rate and weeding frequency was insufficient, and this was an important knowledge gap that was now addressed.

As a result, the current study was started with the following goals in mind:

- To determine the optimum plant population for food barley output in the study area
- To determine the best weeding frequency for food barley production in the research region.
- To analysis how plant population and weeding frequency combine to affect yield and yield components in food barley.

Materials And Methods

The experiment took place in a farmer's field in Charo Kebele, Jimma Geneti District, and Western Ethiopia (Fig 1). It is located at 9°10'0" north latitude and 37°20'0" east longitude. Waina Dega and Dega are the two agro-ecological zones that make up the district. The Waina Dega occupies the majority of the area, accounting for around 60% and Dega for 40%, with an altitude range of 2215 to 3178 meters [27]. During the 2020 rain-fed agricultural season, the experiment was carried out at Charo kebele on a farmer's field with a 5% slope. It is located at $N^0 9^0$ 22.008' latitude and $E^0 37^0$ 06.473' longitude, at an altitude of 2376 meters above sea level. With an elevation of 2301 meters above sea level, Charo kebele lies 1.5 kilometers from Hareto, the district center. And there's an average of 1800mm of rain per year. It also has a temperature difference of 27^0 C and 18^0 C. The experimental site's soil was deep alluvial, with a subsoil stratified with loam, clay loam, and loam dominated by silt loam [46]. Mixed agriculture characterizes the farming method of the community surrounding the area. Farmers plant cereal crops such as Teff, Maize, Wheat, and Barley, as well as pulse crops such as Bean and Pea, and oil crops such as Niger seed.

Materials for Experiments

The experimental material was food barley (Hordeum Vulgare L.) variety HB-1307 received from Bako Agriculture Research Center. Holetta Agricultural Research Center released it in 2006 as a cross between Landrace line and exotic germplasm (Awra Gebs-1 x IBON93/91). Due to its improved grain yield performance, stability, and wider adaption, this variety has been issued in the mid and high altitude range of 2000-3000m above sea level locations. Physical grain quality is good, and it resists leaf rust and scald. It also has moderate resistance to net and spot blotch, lodging tolerance, and a high biomass output. It matures in 135 to 140 days and produces grain yields of 2.8 to 3.5 t ha^{-1} on station and 2.5 to 2.8 t ha^{-1} on farm [47]; [48].

Experimental Design and Treatments

The experiment includes a two-factor combination of four seed rate treatment levels per hectare (115kg, 125kg, 135kg, and 145kg) and three weeding frequencies. Sowing in a randomized complete block design (RCBD) with three replications in a factorial arrangement of 12(4*3). 1W= (One time weeding on thirty (30) days after emergence); 2W= (2ndcycle weeding on twenty-five (25) days after the 1st weeding); FP-0 (Farmers Practice /none/ weeding). Each plot area is made up of ten rows that are 3m long and 2m wide, with an inter raw spacing of 20cm. Blocks and plots are separated by 1 meter and 0.5 meter, respectively. A single plot has a gross area of 6 m2 (3m*2m) and a net plot area of (there is a border impact of 0.1m at all ends of row lengths and widths) 5.04 m^2 2.8 m x 1.8 m. And the entire plot size was (6m2*12plots*3rep.) 216m^2; an experimental total area was 8m*41.5m, or 332 m^2. The entire experimental area is surrounded on all sides by a road that is 0.5m wide. Drilling was used to spread seeds in 20 cm rows.

Information gathered

The following phonological data (days to 50% heading and days to 90% physiological maturity), vegetative and growth parameters (plant height and effective tiller numbers), yield and yield-related parameters (spike length, Number of kernels per spike, 1000-kernel weight, aboveground dry biomass weight, grain yield, straw yield, and harvest index) were gathered. Furthermore, weed metrics such as weed flora identification, weed population, weed density, and weed aboveground dry biomass were gathered and discussed. To estimate the variation in dry matter weight (accumulated owing to competition with the food barley), the weed control efficiency (%) was also determined. Getachew [48] was being used to calculate the competitive ability of weeds at different growth stages as compared to the weedy check [49].

Analysis of the Economic Situation

To establish the economic feasibility of the food barley seed rate and weed management measures, a partial budget analysis was performed as recommended by CIMMYT. The current market prices for inputs at planting and output at crop harvest were used in the economic study. It was calculated by factoring in the additional input and labor costs, as well as the net advantages of weed management measures. The adjusted yield was then multiplied by the price of grain (16 ETB kg^{-1}) to achieve the gross yield benefit; grain yield was then adjusted down by 10% to reflect the difference between well managed and farmer's management techniques. By reducing the entire cost from the gross benefit yield, the net benefit was computed. Finally, by measuring the market at harvest, the mean market price of food barley was determined (2020 cropping season).

Data Analyze

In a Randomized Complete Block Design, measurements were subjected to ANOVA, and analysis was carried out using SAS software version 9.3. [50]. Data's normality was validated during the analysis. The data was evenly dispersed. Fisher's protected LSD-test (5%) was used to differentiate the mean significances of the treatments, and Pearson's correlation analysis was used to examine the relationship between several parameters yield and yield components of food barley.

Results And Discussion

To examine the effect of frequency weeding and plant population, phonological factors such as days to heading and days to physiological maturity, vegetative parameters, yield and yield related parameters, and weed

parameters were evaluated.

Days to 50% heading

The primary effects of weeding frequency and seed rate were found by analysis of variance. 50 percent days to heading at (P <0.01) were highly significant, and their interactions had little effect (Table 1) shows a significant difference for 50% of the days to heading at (P <0.05). The major impacts of one-time weeding on the main effects (weed 30 days post-emergency) and 115 kg ha-1 seed rate, respectively; in comparison to 50% in the past farmer practice (68.83 days) and (65 days from 145 kg ha^{-1} of seed) were recorded esteem (Table 1). It's possible that the early days of 50 percent heading with a higher seeding rate were due to increased weed competitiveness. This provides plants with access to resources such as fertilizer, water, light, and others, allowing them to avoid terminal stress. This finding is consistent with Mulatu and Grando's [6] analysis, which found that the lowest seeding rate, compared to the highest rate on the day to 50 percent heading, caused a delay.

Table 1. Main effects of seed rate and weeding frequency on days to 50% heading.

	Days to 50% heading
Weeding Intensity	
1W	70.00^{b}
2W	71.16^{a}
FP 0	68.83^{c}
LSD (5%)	**0.51**
Seed rates	
115kg	74.55^{a}
125kg	71.66^{b}
135kg	68.77^{c}
145kg	65.00^{d}
LSD (5%)	**0.59**
CV (%)	**0.87**

Days to 90% Physiological maturity

The main impacts of weeding frequency and seed rate were highly significant (P< 0.01), and their interactions were considerably different at (P< 0.05) on days to 90 percent physiological maturity, according to analysis of variance. Physiological maturity in its earliest stage (93.33) and when a plot got the usual farmers' seed rate of 145 kg $ha^{-1,}$ a score of (94.67) was observed. Weeding practice and one-time weeding are two different things (Table 2). The outcome demonstrates that from 115 kg ha-1 to 145 kg ha-1, increasing seed rate reduces days to physiological maturity. Food barley took 116.33 days to 93.33 days to mature (Table 2). This could be related to the fact that as the plant population grew, so did intra-plant competition for limited resources. The findings were consistent with those of Chalachew [51], who observed an increase in seed rate as a result of increased seed rate from 85 kg ha-1 to 150 kg ha-1, days to 90% physiological maturity dropped from 127 days to 90 day 124 days

of food barley The interaction of 2W with 115 kg ha-1 extends the time it takes for food to reach 90% physiological maturity 116.33 days of barley (Table 2). This study's findings are consistent with [28]. Reduced seed rate from 175 kg ha^{-1} to 150 kg ha^{-1}, according to Abiyot, [52] increases the number of days until you reach 90% physiological maturity.

Table 2. Interaction effect of weeding frequency and seed rate on days to 90%

Days to 90% maturity				
Weeding Intensity	Seed rates			
	115kg	125kg	135kg	145kg
1W	113.33^{b}	106.67^{e}	99.67^{gh}	94.67^{ij}
2W	116.33^{a}	109.33^{d}	100.33^{g}	95.67^{i}
FP 0	111.33^{c}	103.67^{f}	98.33^{h}	93.33^{j}
LSD (5%)	1.54			
CV (%)	0.88			

Height of the plant (cm)

The main impacts and interaction effects of seed rate and weeding frequency on mean plant height of the food barley were extremely significant, according to the data (cm). The maximum plant height (128.32cm) and minimum plant height (79.85cm) were obtained from seeding rates of 115 kg ha^{-1} with a weeding frequency of 2W and 145 kg ha^{-1} with a weeding frequency of FP, respectively, according to the interaction result (Table 3). Plant height of barley decreased with increasing duration of weedy periods and increased with increasing duration of weed free periods, according to the results (Table 3). This could be because weed treatment prevented weeds from competing with the crop for growth resources such as light, moisture, soil nutrients, and nutrition, resulting in improved crop growth performance. On the other hand, as the weedy period lengthens, during this time, there was fierce rivalry for environmental resources. Weeds may have taken advantage of the limited light, water, and nutrients for a longer length of time, reducing the plant height of the barley crop. Furthermore, as the duration of weed-free periods has increased, such environmental resources may have been fully exploited by the barley crop for a longer period of time, resulting in an increase in plant height. The results also revealed that treatments that were weed-free for the entire season resulted in a marginal improvement in plant height. Treatments that were left weedy for the entire season, on the other hand, resulted in a drop in barley plant height.

The current experiment's findings are consistent with Zenebech's [53] finds that the maximum and minimum plant heights in the weed-free zone were 107.27 cm and 93.41 cm, respectively, with a competition time of 90 days after emergence (DAE). Plant height in the barley crop dropped as the length of weedy periods (IDWP) rose, but it increased as the duration of weed-free periods increased (IDWFP). Also overlap with the average height of food barley (108.5 cm) [54]. This result is similar to Oerke[34]; Ryan, [37]; Singh, [55], who suggest that low plant height is due to detrimental crop effects induced by weed competition for resources, which reduced crop growth.

The interaction impact of seed rate and weeding frequency also exhibits symbolic differences: as the seed rate of the plant increases, the plant's height drops, and as the weeding frequency increases, the plant's height increases. According to Chalachew [51], the maximum plant height (89.84cm) was obtained from an 85 kg ha-1 seeding rate, while the minimum plant height (80.75cm) was obtained in plots where 150 kg ha^{-1} seeding was used. Food barley seeding rate; the results showed that the lowest seeding rate contributed more to higher plant height in food barley; the maximum seeding density may lead to increased intra-plant competition, which may contribute to plant height reduction.

These findings are consistent with those of Rahel and Fekadu [56] and Teferi [57], who found that increasing the seeding rate can result in shorter bread wheat plants. According to Tewodros [58] and Baloch [59], higher plant density resulted in decreased plant height because high plant density maintains the highest level of resource competition between plants. Similarly, Megersa [60] measured the greatest plant height (115.3 and 116 cm) from two times hand weeded plots. This could be because the lengthening of the weedy season has resulted in fierce rivalry for the sake of the environment Weeds may have taken advantage of the limited light, water, and nutrients for a longer length of time, reducing the plant height of the barley crop.

On the other hand, as the length of weed-free periods has increased, such environmental resources may have been fully utilized by barley for a longer period of time, resulting in an increase in crop plant height. The findings of this study are comparable to those of Hussain [61], who found that increased competition periods resulted in reduced plant height in black seed. Martinkova and Honken [63], who showed a decline in maize plant height as competition length increased, backed up this finding. Similarly, Chauhan and Johnson [64] found that competition with increasing weed density lowered rice plant height considerably. Rice plant height was drastically reduced with weeds, according to Mc Gregor [65].

Table 3. Interaction effect of weeding frequency and seed rate on plant height.

Plant height (cm)				
Weeding Intensity	Seed rates			
	115kg	125kg	135kg	145kg
1W	119.20^{b}	105.23^{e}	88.21^{h}	82.93^{k}
2W	128.32^{a}	108.12^{d}	91.66^{g}	84.53^{j}
FP 0	113.19^{c}	93.47^{f}	86.36^{i}	79.85^{l}
LSD (5%)	0.98			
CV (%)	0.59			

Effective tiller number

The main effects and interaction effects of seed rate and weeding frequency on the number of effective tillers of food barley were extremely significant (P< 0.01). The maximum and lowest effective tiller numbers were 4.86 and 0.17, respectively, according to the interaction obtained from the interaction of 115 kg ha^{-1} seed rates with 2W and 145 kg ha^{-1} seed rates with FP correspondingly (Table 4). According to the results of an experiment, the number of efficient tillers is when seed rate is increased from 115 kg ha^{-1} to 145 kg ha^{-1}, it drops from 4.86 to

0.17% (Table 4). It's possible that when the seeding rate increased, the number of effective tillers decreased to the crop's tiller ability; planting density; and competitive issues such as weeds for lack of space, there is an infestation. This result was consistent with Intisar [65] and Seleiman [66] findings. Farther, in agreement with Turk [68], who stated that the number of tillers increase as seed rate decreases. The number of effective tillers per plant rose as a result of the current findings. Weeding occurs more frequently (Table 4). This corresponds to the maximum (Megersa [61]. The highest number of tillers was reached after hand weeding two times were mostly due to improved crop growth as a result of reduced weed competition. This is in line with the findings of Ijaz [67], who found that better weed control improves soil quality enhanced the crop's nutritional availability It was also in line with the investigation of Amare and Kiya [69], the maximum number of effective tillers in weed-free areas It's possible that the treatment is due to the limited availability of growth nutrients for the crop in question.

As weeds, they efficiently utilized all of the growing resources available to them. By removing them from the field on a regular basis, they are kept out of harm's until harvest; see also Mubeen [70]; (Bekele [71]. In addition, Ijaz [67] found that weed-free periods enhanced nutrient levels availability to the crop, resulting in an increase in the number of tillers. The results have been in agreement with Chandramohan [72], who found that weeds compete with grasses. Reduce tillering by competing with crops for resources such as light, nutrients, moisture, and space crop plants' capacity Takele [22] observed a decrease in the number of tillers in the field increasing weed population in barley. Many yield contributing agents influence crop yields in general. Among them are because of their contribution to final yield, the number of effective tillers is the most critical. The decline in the number of tillers beyond the 115 kg ha^{-1} seeding rate could be attributed to a lot of rivalry among the plants for food barely.

The number of effective tillers had been Weeding time has an impact. Early weeding has a favorable impact on the environment, according to the findings. Food barley is being tilled. The result shows that there are more effective tillers (6.06) at this location. Farmers' tactics included frequent two-time weeding (2W) but a smaller number of tillers (0.42).The findings of Durem Wheat, as reported by Haile and Girma, [73] also confirmed.

Length of spike (cm)

The main effects and interaction effects of spike length were found in the analysis of variance. The effects of seed rate and weeding frequency on spike length were highly significant ($P < 0.01$) of barley for food barley. The maximum spike length (8.82cm) and the shortest spike length (8.82cm) (5.32 cm) on 115 kg ha^{-1} with 2W and 145 kg ha^{-1} with farmers were achieved from planting rates of 115 kg ha^{-1} with 2W and 145 kg ha^{-1} with farmers practice in accordance with (Table 4). It was reduced from 8.82 cm to 5.32 cm as a result of the findings. On seed rates of 115 kg ha^{-1}, the data showed that it was reduced from 8.82 cm to 5.32 cm 145 kg ha^{-1} and 145 kg ha-1, respectively (Table 4). This could be owing to the fact that there is greater open space between plants at this time of year. Seed rates are lower, and there is less intra-plant competition for available resources. As a result, the spike length increased. The current outcome agrees with Gafaar's conclusion [74], increasing sowing density lowered spike length considerably. In addition, Teferi [75] indicates in accordance with current results. Those with the longest spikes (7 cm) were measured from a plots that were seeded at a rate of 75 kg ha^{-1} with a minimum spike length of 6 cm acquired from plots where a seed rate of 150 kg ha^{-1} was applied. The outcome was also in line with expectations Santosh [76] discovered that by employing the same amount of chemical fertilizer, the greatest yield could be achieved. Using the frequency of planting, the spike length (10.9 cm) was

measured in the days leading up to 90 days after sowing. Farmers provided the minimum spike length (8.3 cm) and two times manual weeding practices.

Table 4. Interaction effect of weeding frequency and seed rate on effective tiller number and spike length of food barley.

Weeding Intensity	Seed rates							
	Effective Tiller number				Spike length (cm)			
	115kg	125kg	135kg	145kg	115kg	125kg	135kg	145kg
1W	3.77^{b}	2.80^{d}	1.76^{f}	1.20^{gh}	7.49^{d}	7.50^{d}	7.39^{d}	6.27^{g}
2W	4.86^{a}	3.26^{c}	2.25^{e}	1.42^{g}	8.82^{a}	8.29^{b}	7.87^{c}	6.83^{f}
FP 0	0.92^{hi}	0.65^{ij}	0.43^{jk}	0.17^{k}	7.12^{e}	6.16^{gh}	5.99^{h}	5.32^{i}
LSD (5%)	0.30				0.23			
CV (%)	9.17				1.98			

Number of kernels per spike

Grain per spike is affected by the number of grains per spike, which is a significant yield contributing component. The main impacts of weeding frequency and seed rate were very significant (P <0.01), and their interactions were considerably different (P< 0.05) on the number of kernels per spike of the food barley, according to analysis of variance. Seeding rates of 115 kg ha^{-1} with 2W and 145 kg ha^{-1} with farmers practice yielded the maximum number of kernels per spike (67.40) and the lowest number of kernels per spike (39.06), respectively (Table 5).

The number of grains per spike fell by 39.63 percent as the seeding rate increased from 115 kg ha^{-1} to 145 kg ha^{-1} (Table 6). These results could be attributed to better availability of growth materials at a lower seeding rate, which could have led in an increase in chlorophyll, resulting in a higher photosynthetic rate and higher photosynthetic rate. Eventually, there will be more photosynthesis available for sink development during grain formation. Teferi [75] found that the number of grains per spike produced from seeding rates of 100 kg ha^{-1}, 125 kg ha^{-1}, and 150 kg ha^{-1} from food barley was 50.93, 44.2, and 39.7, respectively; the number of grains per spike reduced by 22.05% between the highest and lowest.

Megersa [60] observed a similar result, with the largest amount of grain per spike (51.1) obtained from plots treated with two times hand weeding and the lowest quantity of grain per spike (42.2) acquired from un-weeded plots. A similar conclusion was reached by Chaudhry [77]; Bostrom & Fogelfors, [78]; Khan and Rashid, [79]. The lowest grains reported in untreated plots could be owing to intense weed competition between weeds and crop, which significantly lowered grain yield. This decreased grain yield in untreated plots could be owing to strong weed competition between the weeds and the crop, which impeded nutrient mobility to the grains and harmed the barley crop's grain growth potential.

In addition, as stated by Megersa [60], a significantly higher number of grains could be the result of easily accessible growth factors (nutrient, moisture, and light) for individual plants that retained more flowers and had a higher net assimilation rate in the absence of weed competition. In addition, the development of larger and

vigorous leaves under low weed infestation may have aided in improving the crop's photosynthetic efficiency and supporting a bigger number of grains. Also supports Essam and Abd's [80] findings that the larger grain number obtained at the lowest seed rate can be attributable to more light penetration through the plant canopy.

Thousand kernels (gm)

The main effects and interaction effects of seed rate and weeding frequency had high significant (P< 0.01) effects on thousand kernel weight of food barley, according to the analysis of variance. From seed rates of 115 kg ha^{-1} with 2W and 145 kg ha^{-1} with FP, the highest thousand kernel weight was 49.97gm and the minimum thousand kernel weight was 31.30gm (Table 5). This could be owing to a high density generated by an increase in the total number of tillers, which would increase competition and leave little photosynthesis available for grain filling, resulting in a reduction in the weight of thousands of kernels. The highest thousand kernel weight 42.82gm and the minimum thousand kernel weight 40.56gm were reported from seed rates of 125 kg ha^{-1} and 150 kg ha^{-1} of food barley, respectively, according to Teferi [75].

The weight of a thousand kernel was lowered by a factor of ten (5.27%). Teferi [75] found that increasing the seeding rate from 75 to 100, 75 to 125, and 75 to 150kg ha^{-1} resulted in a 3.12, 7.36, and 12.25 percent drop in thousand seed weights, respectively. This could be due to greater resource competition inside and between plants as a result of the increased number of plants per unit space. Similarly, Baloch [59] found that when seeding rate increased, thousand seed weight decreased.

Similarly, weeding frequency has an impact on thousand kernel weights, as the second weeding (2W) occurred twenty-five (25) days following the first weeding (2W) and resulted in a maximum thousand kernel weight of 49.97gm, while the minimum kernel weight was 31.30gm, according to farmer practices (FP) (Table 6). The maximum thousand kernel weight 43.3gm and the minimum thousand kernel weight 31.7gm (reduced by 26.79 percent) were recorded from two times hand weeded plots (might be the continuous removal of weeds through manual weeding which favors healthy crop growth and suppresses further establishment of weeds) and un weeded plots, respectively, according to Megersa [60]. The results were also similar to those of Jemal [81], who found that increasing seeding rate decreased 1000-kernelweight considerably.

Table 5. Interaction effect of weeding frequency and seed rate on number of kernels per spike and thousand kernel weight of food barley.

	Seed rates							
Weeding Intensity	Number of kernels per spike				1000 kernel weight (gm)			
	115kg	125kg	135kg	145kg	115kg	125kg	135kg	145kg
1W	55.80^{b}	51.10^{cd}	49.36^{cdef}	48.06^{def}	47.46^{b}	43.15^{d}	39.13^{f}	35.39^{h}
2W	67.40^{a}	56.03^{b}	$53.13b^{c}$	50.23^{cde}	49.97^{a}	45.55^{c}	41.24^{e}	37.59^{g}
FP 0	46.36^{ef}	46.10^{f}	41.70^{g}	39.06^{g}	34.47^{i}	33.29^{j}	32.52^{k}	31.30^{l}
LSD (5%)	4.02				0.50			
CV (%)	4.72				0.77			

Dry biomass weight above ground (kg ha^{-1})

The main effects and interaction effects of weeding frequency and seed rate on above ground dry matter demonstrated very significant differences (P<0.01), according to analysis of variance.

The highest and lowest biomass yields (13689) were shown by the interaction effect. The interaction of seeding rate of 145 kg ha^{-1} and (7667 kg ha^{-1}) yielded the results (kg ha^{-1}) and (7667 kg ha^{-1}).115 kg ha^{-1} with FP and 2W, respectively (Table 6).

The increased biomass production could be ascribed to the increasing plant population as a result of climate change to a higher planting rate and weed control that is effective crop yield has a strong influence on biomass yield.

The current outcome is consistent with the findings of Teferi [75], biomass yield increased linearly from 8.26 to 16.47 tons ha^{-1} as the sowing rate of food barley rose from 75 kg ha^{-1} to 150 kg ha^{-1}, respectively. This could be because increased seeding rates result in a higher plant population. As a result, the straw yield increased. In a similar vein, this result agrees with Jemal [81] found that greater seeding rates resulted with higher biomass and biological yields. Furthermore, the current result agrees with Amare and Kiya's [69] maximum value. Weedy biomass yields of 4386.13 kg ha^{-1} and 3417.10 kg ha^{-1} were obtained from the period of frequency, and from the un-weed check treatment, respectively.

The length of the weed-free period determines the outcome. In general, extended weed competition has a negative impact resulting in lower biomass accumulation, shorter spike length, and lower thousand kernel weight at the end, this resulted in a decreased grain yield.

Grain yield (kg ha^{-1})

Analysis of variance showed that the main effect of seeding rate and weeding frequency had highly significant difference (P < 0.01) on grain yield. And also, the interaction effect of seeding rate and weeding frequency showed highly significant effect (P < 0.01) on grain yield of the food barley. The highest grain yield (4750 kg ha^{-1}) and the lowest grain yield (1833.3 kg ha^{-1}) was obtained from seeding rate of 145kg ha^{-1} with 2W and seeding rate of 115 kg ha^{-1} with farmers practice respectively (Table 6). Grain yield is a function of the integrated effect of the yield components which were influenced differently by growing conditions. The maximum grain yield obtained from the use of higher seeding rate might be due to high density of plants in rows and increased number of spikes per rows (Table 6). Similar to the present finding, Teferi [75] the minimum grain yield (2.89 ton ha^{-1}) and the maximum grain yield (6.23 ton ha^{-1}) was recorded from seed rate of planted with 75 kg seed rate ha^{-1} and 125kg seed rate ha^{-1} of the food barley respectively, the higher grain yield in the higher seeding rates was associated with higher spike number or plant population ha^{-1}. The present result is also in agreement with Haile [86] who reported that grain yield reduced with low seeding rate depending on the variety, soil fertility, weed management and the suitability of the growing environment. Also, according to Zenebech, [53] the maximum grain yield (5595 kg ha^{-1}) was recorded from weed free plot until 70 to 90 days, and the minimum grain yield (1666.7 kg ha^{-1}) was recorded from the un weeded plot (weedy check) barley grain yield decreased with prolonged delays in weed removal; conversely, grain yield increased with the increasing length of weed-free period. The present result was also in line with the findings of, Haile [86] who reported that the lowest seeding

rate (100 kg ha^{-1}) resulted in a grain yield of 38.51 tons ha^{-1}, which was significantly lower than the yields obtained at the other seeding rates (150 and 175 kg ha^{-1}). Likely, Abiyot, [52] reported that grain yield increased as seeding rate was increased from 50 to 150 and from 100 to 150 kg ha^{-1}, respectively. Contrarily to this, Amare and Kiya, [69] reported that Maximum grain yield (3.69 ton ha^{-1}) was recorded from a seed rate of 100 kg ha^{-1} of wheat. Even if, in the higher seed rate there is a presence of competition between plants for common resource like moisture, nutrients and also light. In the analyzed data shown by (Table 6) as seed rate increases from 115 kg ha^{-1} to 145 kg ha^{-1} also the grain yield increases from 1833.3 kg ha^{-1} to 4750 kg ha^{-1}, similarly the weeding frequency also increases from Farmers Practice none (zero) weeding (FP) to 2nd weeding on twenty five (25) days after the 1st weeding (2W) (Table 6). This result shows for the well obtained grain yield, beside the increment of seed rate, the weeding frequency had a great role. The decrease in yield with the increase in the duration of competition might be the result of increased weed dry weight and weed population, which might have influenced the number of productive tillers m^{-2} and per grain spike. The present result was in line with the findings of Merhawit, [82] reported as Wheat grain yield decreased with prolonged delays in weed removal; conversely, grain yield increased with the increasing length of weed-free period.

Table 6. Interaction effect of weeding frequency and seed rate on above ground total biomass weight and grain yield.

Weeding Intensity	Above ground total biomass weight (kg ha^{-1})				Grain yield (kg ha^{-1})			
	115kg	125kg	135kg	145kg	115kg	125kg	135kg	145kg
1W	8200^{h}	9628^{e}	10406^{d}	12133^{b}	2861.1^{h}	3583.3^{f}	4016.7^{d}	4488.9^{b}
2W	8700^{g}	10117^{d}	11128^{c}	13689^{a}	3250.0^{g}	3833.3^{e}	4333.3^{c}	4750.0^{a}
FP 0	7667^{i}	7844^{i}	9089^{f}	9267^{f}	1833.3^{l}	2083.3^{k}	2277.8^{j}	2500.0^{i}
LSD (5%)	323.42				122.12			
CV (%)	1.94				2.17			

Straw yield (ton ha^{-1})

The main effect of seeding rate and weeding frequency shows highly significant (P<0.01) effect on straw yield of food barley. Similarly, the interaction effect of seeding rate and weeding frequency shows highly significant (P<0.01) on straw yield. The maximum straw yield 8.12 ton ha-1 which was obtained from higher seed rate 145 kg ha^{-1} and the minimum straw yield 5.48 ton ha^{-1} which was recorded from lower seed rate 115 kg ha^{-1} were obtained from 2nd weeding on twenty five (25) days after the 1st weeding (2W) and Farmers Practice (FP) respectively (Table 7). This may be shows that as weeding frequency increases on the weeded plots, reduces the competition of weeds, facilitates tillering capacity of the plant and then, the straw yield becomes increased than the farmers practiced plots (Table 7).

In general, increased seed rate from 115 kg ha^{-1} to 145 kg ha^{-1} increases straw yield 5.48 tons ha^{-1} to 8.12 tons ha^{-1} increased by 32.52%. There was a linear increase in straw yield as the seeding rate and weeding frequency

were increased consequently. This is might be due to the fact that higher seeding rates result in more plant population and greater plant height which resulted in higher straw yield (Table 7).

Similar results were reported by Teferi [75] the highest straw yield (10.5 ton ha^{-1}) and the lowest straw yield (5.38 ton ha^{-1}) were recorded from seeding rate of 150 kg ha^{-1} and 75 kg ha^{-1} of food barley respectively; There was a linear increase in straw yield as the seeding rate increased from the 75 to 150 kg ha^{-1}. This might be due to the fact that higher seeding rates resulted in more plant population which resulted in higher straw yield. This result is in harmony with Ali [25] who reported that as seeding rate increased, correspondingly straw yield increased due to higher stand number at crop establishment period. Similarly, Worku [83] reported that as seeding rate increased, correspondingly straw yield increased due to higher stand number at crop establishment period.

Harvest index (%)

The higher the harvest index value, the greater the physiological potential of the crop for converting dry matter to grain yield. As showed analysis variance of the harvest index, the main effects and interaction effect were highly significantly ($P<0.01$) affected by weeding frequency and seed rate of the food barley. The highest harvest index 37.01% and the lowest harvest index 24.08% were obtained from seed rate of 145 kg ha^{-1} with plots weeded two times (2W) after seedling emergence and seed rate of 115 kg ha^{-1} from plots of farmer practice (FP) respectively (Table 7).The result also showed that, as the seed rate increases from 115 kg ha-1 to 125 kg ha^{-1} on weeding frequency of 1W the harvest index changes 34.24 to 35.92%, on weeding frequency of 2W the harvest index changes 35.74 to 36.34% (Table 7). Also the result showed that, as the seed rate increases from 135 kg ha^{-1} to 145 kg ha^{-1} on weeding frequency of 1W the harvest index changes 35.45 to 35.56%, on weeding frequency of 2W the harvest index changes 35.58 to 37.01% (Table 7).This result shows with in increasing the weeding frequency, also increasing the harvest index of the food barley. The ability of cultivar to convert the dry matter into economic yield is indicated by its harvest index.

The higher the harvest index value, the greater the physiological potential of the crop for the converting dry matter to grain yield. Harvest index is an indicator of plant efficiency to distribute dry matter in grain [84]. Similar results were reported by Megersa [60] two times hand weeding produced significantly maximum harvest index (47.3%) whereas the minimum (22.0 %) was obtained from weedy check plots. In addition he reported that twice hand weeding showed the highest harvest index (46%) than other treatments on the same variety.

The present study in agreement with the findings, Haile [73] who reported that the lowest seeding rate (100 kg ha^{-1}) resulted in harvest index of 3.851 tons ha^{-1}, which was significantly lower than harvest index obtained at the other seeding rates (150 and 175 kg ha^{-1}). Likely, Burgos [85] and Abiot [52] reported that harvest index increased as seeding rate was increased from 50 to 100 kg ha-1 and from 100 to 150 kg ha^{-1} respectively.

Table 7. Interaction effect of weeding frequency and seed rate on straw yield and harvest Index

Weeding Intensity	Seed rates								
	Straw yield (ton ha^{-1})					Harvest Index (%)			
	115kg	125kg	135kg	145kg		115kg	125kg	135kg	145kg
1W	5.60^{fg}	6.38^{de}	7.31^{b}	8.07^{a}		34.24^{c}	35.92^{b}	35.45^{b}	35.56^{b}
2W	5.83^{f}	6.71^{c}	7.84^{a}	8.12^{a}		35.74^{b}	36.34^{ab}	35.58^{b}	37.01^{a}
FP 0	5.48^{g}	5.75^{fg}	6.18^{e}	6.67^{cd}		24.08^{e}	26.55^{d}	26.90^{d}	27.21^{d}
LSD (5%)	0.29					0.95			
CV (%)	2.62					1.73			

Weed flora

The major weed species identified in the experimental site were Guizotia scabra (tufo guracha) 20.89% with population density 1345, Phalaris paradoxa L.15.76% with population 1015, Anagallis arvensis 11.36% with population density 731, and Amaranthus spp 7.03% with population density 452, dominating the experimental area in decreasing order (Table 8). While weed species like Polygonum nepalense (437), Sogide (414), Commel benghalensis L. (400), Chrysanthemum segantum (348), Plantago lanceolata (336), Lolium temulentum L. (269), Guizotia scabra /Hada/ (238), Avena fatua L. (213), Raphanus raphanistrum (156) and (86) are others weed species. This are dominating the area in minor number of population. In general broadleaved weed species were more dominated (69.26%) the experimental field than Grass weed species (29.46%) and others weed species (1.28%) (Table 8). Similar findings were reported by Amare and Kiya, [69] a total of 13 weed species belonging to seven families comprised of seven grasses (54%), 5 broadleaved (38%) and 1 sedge (8%) were recorded from food barley. Also, according to Merhawit, [82] and likewise Burgos [85], reported that broadleaved weed (72%) and Grass (24%) dominated from the total weed spectrum, whereas sedges (4%) were minor. Similar investigation by Dawit [86] shows that experimental field were found to be infested with weeds comprising of broadleaved and grass. Climate changes that, crop history and agronomic practices are the most probable reasons for the variation in weed population

Table 8. Weed population found in the experimental area during 2020 cropping season.

Local name	Scientific name	Group	Population observed	Relative density%
Tuufoo gurraacha	*Guizotia scabra*	Broad leaved	1345	20.89
Tuufoo diimaa (Hadaa)	*Guizotia scabra*	Broad leaved	238	3.69
Goommanee	*Raphanus raphanistrum*	Broad leaved	156	2.43
Dinbilaalee	*Chrysanthemum segantum*	Broad leaved	348	5.41
Cuqqaallii Dinnichaa	*Anagallis arvensis*	Broad leaved	731	11.36
Qeroo	*Phalaris paradoxa* L.	Grass	1015	15.76
Ajanbila	*Avena fatua* L.	Grass	213	3.31
Booqee	*Polygonum nepalense*	Broad leaved	437	6.78
Soogiddee	-	Broad leaved	414	6.44
Ajaahaa	*Amaranthus spp*	Broad leaved	452	7.03
Inkirdaada	*Lolium temulentum* L.	Grass	269	4.17
Qorxobbiii	*Plantago lanceolata*	Broad leaved	336	5.23
Sissiiqaa	*Commel benghalensis* L.	Grass	400	6.22
Others	-	-	83	1.28
Total			6437	100

Weed relative density (%)

Analyzed data indicates that the main effect of weeding frequency and seed rate of the food barley showed highly significant ($P < 0.01$) effect on relative weed density. However; the interaction effect of weeding frequency and seed rate of the food barley were not significant ($P < 0.05$). Maximum relative weed density (5.67%) was observed on the farmer practice (FP). Whereas the lowest relative weed density (0.50%) was observed on the treatment which was weeded two times (2W) after seedling emergence (Table 9). Early weeding one times on thirty days after emergency show higher 2.14% relative weed density than weeding second on twenty five (25) days after the 1st weeding (0.50 %) after emergence (Table 10). This implies that increasing weeding frequency to be weeded from 1W to 2W after emergence was reduced weed relative density. Regarding with seed rate, the highest weed relative density 3.50%, and the lowest weed relative density 2.21% (Table 9); this implies that, as seed rate increases, the weed relative density decreases. Similar result was reported by Megersa [60] the minimum total weed density (13.3 m^2) was recorded in two times hand weeded plots, whereas, the maximum total weed density (49.5 m^2) was observed from weedy check plots (farmers practice). This minimum numbers of weed density may be attributed to effectiveness' of management practices. The reason of low density of weed species in two times hand weeded plots might be the continuous removal of weeds through manual weeding which favor health crop growth and suppressed further establishment of weeds. This result is supported by the results of Singh and Pillai [60] and was reported as the smallest weed density was recorded at application of topic at 30 day and highest weed density was recorded on control.

Table 9. Main effects of seed rate and weeding frequency on weed relative density.

Weeding Intensity	Weed relative density
1W	2.14^{b}
2W	0.50^{c}
FP 0	5.67^{a}
LSD (5%)	**0.42**
Seed rates	
115kg	3.50^{a}
125kg	2.84^{b}
135kg	2.53^{bc}
145kg	2.21^{c}
LSD (5%)	**0.48**
CV (%))	**17.98**

Weed control efficiency (%)

There was highly significance difference (P< 0.01) on main effect of weeding frequency and seed rate on weed control efficiency. Also, the interaction effect of weeding frequency and seed rate was highly significance difference (P < 0.01) on weed control efficiency of the food barley. Significance differences were observed by various weeding frequency, weeding one times after seed emergence, weeding two times after seed emergence compared with farmer practices. Maximum weed control efficiency (85.90%) was observed at weeding two times after seed emergence, which was statistically at par with weedy up to two times (84.87%) after seedling emergence (Table 10). While minimum control efficiency (13.58%) was recorded at weeding one times after seed emergence and farmer practices with (0.00%) (Table 10). Increasing days of weeding frequency from weeding one times after seed emergence to weeding two times after seed emergence increases controlling efficiency. The result was in agreement with the investigation of Merhawit, [82] reported as weed control efficiency decreased with the increase in duration of the weedy period and increased with the increase in duration of the weed-free period. Weed control efficiency was inversely related to the dry matter accumulated by weed.

Weed above ground biomass (gm^{-2})

There was highly significance difference (P < 0.01) on main effect of weeding frequency and seed rate on weed aboveground dry biomass. Also, the interaction effect of weeding frequency and seed rate was highly significance difference (P< 0.01) on weed aboveground dry biomass of the food barley. The result showed that, the highest weed aboveground dry biomass 494.44 gm^{-2} was recorded from seed rate of 115 kg ha^{-1} plots obtained from farmers practice (FP) (Table 10) while the minimum weed aboveground dry biomass 21.39 gm^{-2} was recorded from plots of seed rate 145 kg ha^{-1} on weeding frequency of two times weeding after seedling emergence (2W) (Table 10). The result also showed that, as the seed rate increases from 115 kg ha-1 to 145 kg ha^{-1} , the weed aboveground dry biomass decreases from 494.44 gm^{-2} to 21.39 gm^{-2} and similarly, as weeding frequency increases from (FP) to (2W), the weed aboveground dry biomass also decreases (Table 10). This shows increasing seed rate increases intra-row competition for resources that might be reduces weed dry matter

accumulation and late emerging soil seed bank weeds suppressed by crops not to be storing strong enough dry biomass. At earlier, hand weeding controlled the emerged weeds and those that emerged later might have failed to accumulate sufficient dry matter due to the competition offered by well growing crop plants. Further, the weed seeds under soil seed bank that might be have been brought to the upper soil layer by hand weeding, germinated and emerged later, but were in their initial growth stage accumulate less dry weight and weeded by manual hand of the second cycle and Weed dry weight decreased significantly with the successive increases in the weed-free period. The result was in agreement with the findings of Merhawit, [82] that was reported as weed competition from 15 to 30 days had no significant differences in total dry weight of weed. However, beyond 45 days up to weedy check throughout the growing season increased significantly. This result also in harmony with those reported by other investigator Anwar [96] where they reported an increase in weed dry weight with increasing weedy period as a result of prolonged weed growth period. Similar result was reported by Anwar [87] and Getachew [48] who observed that weed density and dry weight decreased with increasing duration of weed-free period in an experiment conducted to determine the critical period of weed control in rice. The results are in accordance with those of Dawit [86] who reported that an increase in weed dry weight with increased competition periods in black seed and fennel crops respectively. Ryan, [36] also reported that the dry matter production in rice decreased due to weed competition as a consequence of disturbance in nutrient supply and distribution, lower water potential which resulted in reduced growth and straw production.

Table 10. Interaction effects of weeding frequency and seed rate on weed control efficiency and weed above ground dry biomass.

Seed rates									
Weeding Intensity	Weed control efficiency (%)					Weed above ground dry biomass (gm/m^2)			
	115kg	125kg	135kg	145kg		115kg	125kg	135kg	145kg
1W	50.54^{c}	41.81^{d}	13.58^{f}	23.58^{e}		244.44^{c}	208.33^{d}	158.33^{ef}	108.33^{g}
2W	83.71^{ab}	85.90^{a}	79.66^{b}	84.87^{ab}		80.56^{h}	50.94^{i}	37.22^{ij}	21.39^{j}
FP 0	0.00^{g}	0.00^{g}	0.00^{g}	0.00^{g}		494.44^{a}	361.11^{b}	183.33^{de}	141.67^{f}
LSD (5%)	5.59					26.23			
CV (%)	8.55					8.90			

Cost and Benefit Analysis

Getting higher profitability lies not only in using appropriate agronomic management but also in lowering costs per unit crop production through higher yields. Therefore, economic analysis is required for making recommendation for farmers from such agronomic experiments. In practice, not all farmers, however, can aim for the largest net benefits because of the generally larger costs involved to other risks associated with farming. The cost and benefit analysis result indicated that the highest net benefit (51015 ETB ha^{-1}) was obtained from the treatments sown with seed rate of 145 kg ha^{-1} weeded 2nd weeding on twenty five (25) days after the 1st weeding while the lowest net economic net benefit was recorded sown from 115 kg ha^{-1} with Farmer practice (15814.6 ETB ha^{-1}) (Table 11).

Table11. Gross net benefit as influenced by weeding frequency and seed rate in Food barley production based on total weed management cost and gross field benefit of the crop.

Treatments	Yield (kg ha^{-1})	AY (kg ha^{-1})	GB (ETB)	TC (ETB)	NB (ETB ha^{-1})
FP0 115 kg	1833	1649.7	26395.2	10580.6	15814.6
FP0 125 kg	2083	1874.7	29995.2	10790.1	19205.1
FP0 135 kg	2277	2049.3	32788.8	10988.6	21800.3
FP0 145 kg	2500	2250	36000	11192.7	24807.3
1W 115kg	2861	2574.9	41198.4	12784.2	28414.2
1W 125 kg	3583	3224.7	51595.2	13087.1	38508.1
1W 135 kg	4016	3614.4	57830.4	13332.9	44497.5
1W 145 kg	4488	4039.2	64627.2	14791.3	49835.9
2W 115 kg	3250	2925	46800	14861.2	31938.8
2W 125 kg	3833	3449.7	55195.2	15136.6	40058.6
2W 135 kg	4333	3899.7	62395.2	15395.6	46999.6
2W 145 kg	4627	4164.3	66628.8	15613.9	51015

Conclusion And Recommendations

Production and productivity of food barley is low due to many biotic and a biotic factor among which agronomic practice like seed rate and weed problems are the major constraints. However; information in relation to proper use of seed rate and proper weeding frequency in this particular study area was lacking and this was an important knowledge gap addressed currently. The present study was conducted at Jimma Geneti District, western Ethiopia under rain fed condition during 2020 main cropping season to assess the effect of seed rate and weeding frequency on yield and yield components of food barley. Food barley variety which was released by Holeta Agricultural Research Center in 2006 was used as test material. An experiment consists of two treatment combination, four treatment levels of seed rates and three treatment level of weeding frequency in randomized complete block design with three replications in factorial arrangement.

The result of the study indicates grain yield was highly and significantly ($P < 0.01$) affected by main factors of seed rate and weeding frequency. Higher grain yield was harvested from 145 kg ha^{-1} seeding rate than the others and 4750 kg ha^{-1} grain yield was harvested from treatments weeded two times (2W) after emergence. Harvest index, thousand seed weight, above ground dry biomass, grain yield, effective tiller number, plant height, spike length, straw yield, weed control efficiency and weed above ground dry biomass were affected high significantly ($P<0.01$) by both the main affects and the interaction effects of weeding frequency and seed rates. Days to 90% physiological maturity and number of kernels per spike were affected high significantly ($P<0.01$) by the main affects and significantly ($P<0.05$) by interaction effects of weeding frequency and seed rates. On the other hand, days to 50% heading and weed relative density did not significantly influenced the interaction affects by seed rates and weeding frequency. Weeding two times after emergence took the longest period of time (116.33) days to maturity under 115kgha^{-1} and shortest days (93.33) to maturity were observed at 145 kg ha^{-1} under farmer practices.

Thirteen weed species were infested the food barley crop at the experimental site. The major weeds in the experimental site included, broadleaved and Grass weeds. Among all weed species *Guizotia scabra (tufo guracha)*, *phalaris paradox*, *Anagallis arvensis,* Amaranthus spp, *polygonum nepalense*, *soogide*, *plantago lanceolata*, and competing vigorously with food barley crop the most dominant weed species was *Guizotia scabra* with the highest relative density of 20.89% at Jimma Geneti. Minimum relative weed density (1.28%); Weed above ground dry biomass the minimum (21.39 gm m^{-2}) and maximum weed control efficiency (85.90%) was recorded from weeding two times after emergence.

From the result of the study the following can be concluded that treatments which are taking highest seed rate (145 kg ha^{-1}) gives higher grain yield than 115 kg ha^{-1}, 125 kg ha^{-1} and 135 kg ha^{-1}. Therefore increasing seed rate more preferable in production of higher grain yield of food barley. Because high amount of seed rate produces higher crop stand as well higher spike and spikelet per spike. Weeding two times (2W) after emergence resulted in higher grain yields, harvest index and lower weed relative density, and higher weed control efficiency for the matter that early weeding encourages late emerging soil weed seeds that are computing for food barley for long period during its life time.

In general, the result of the experiment indicates that maximum yield loss due to un weeding (farmers practice) and late weeding after emergence of 30days (1W) was 61.41% and 60.23% when compared with 145 kg ha^{-1} seed rate was used with weeding two times (2W) after emergence respectively. To prevent more than 10% yield loss the efficient weed control methods for food barley variety HB 1307 could be under taken by keeping the crop weed free after emergency of the crop weeding two times (between 30-55 days) with 145 kg^{-1} seed rate. However as this experiment was done at one site for one season, the experiment has to be re tested over site all season to reach at conclusive recommendation.

Declarations

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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Figures

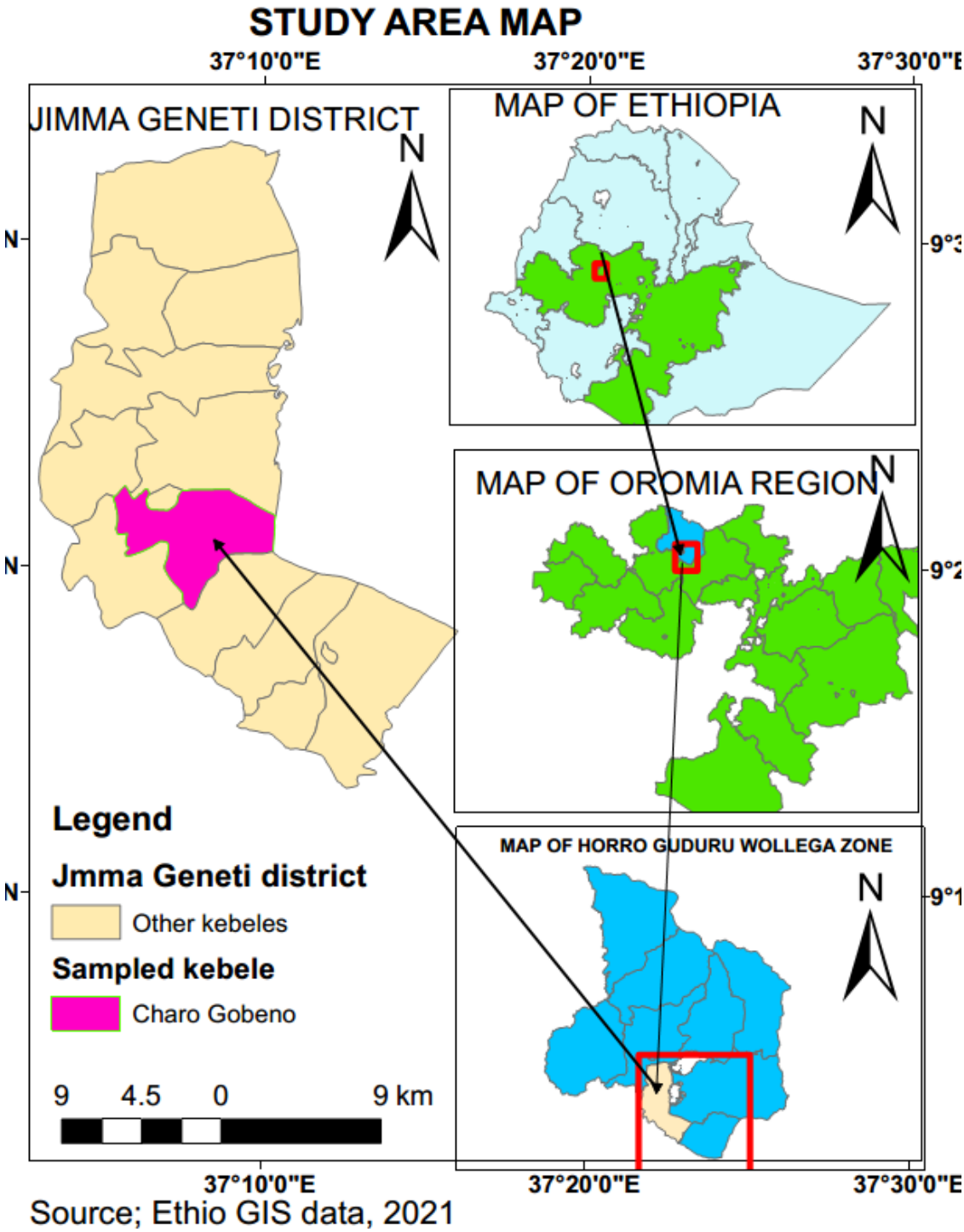

Figure 1

Map of the study area, Western Ethiopia, Jima Genet District, Charo Koticha Kebele