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Evaluation of Agro-Morphological Traits of Food Barley (Hordeumvulgare L.) Varieties in Different Row Spacing in Bure District, North-Western Ethiopia

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Abstract
The average national yield of barley is low due to biotic and abiotic factors. This low productivity can be increased through improved agronomic management practices such as adjusting optimum row spacing and introduce improved varieties. The experiment was conducted in Bure district specifically Wangedamkebele, West Gojjam Zone, Northwestern Ethiopia in 2016/17 main cropping season. The objective was to evaluate the effects of inter row spacing and variety types on agro-morphological traits and to determine the optimum row spacing and variety for maximum productivity of food barely. Randomized complete block design in factorial arrangement with three replications was used for the experiment. The spacing used in the experiment was 20cm, 25cm, 30cm and35cm and the varieties used were Abay, HB 1307 and Setegn. The variety HB 1307 gave significantly highest grain yield with 35cm row spacing. The lowest grain yielding was obtained from Abay variety within 20cm.Main effects was recorded a significant ($p<0.05$) difference for all parameters. The interaction effects also showed significant difference for spike length, biological yield, grain yield, straw yield and harvest index. Correlation coefficients among the parameters were revealed that grain yield was highly significant and positive correlated with biological yield (r=0.81), effective tiller numbers (r=0.80), harvest index (r=0.74) and spike number (r=0.81), and significant with thousand kernel weight (r=0.39) and spike length (r=0.27). This finding showed that interactive effect of HB 1307 with 35cm row spacing was superior for achieving higher yield in the study area. However, further study has to be done under different locations and season to exploit tentative recommendation of the present stud.
Keywords: Grain yield, Improved varieties, Parameters.

1. INTRODUCTION

Barley (*Hordeum vulgare* L.) is the fifth most important cultivated crop of the world (Engles, 2012). In Ethiopia, barley is ranked fifth of all cereals, based on area of production, but third based on yield per unit area (Bayeh and Grando, 2011). Barley covers 10% of the land under crop cultivation (ICARDA, 2013). Barley is a hardy crop grown in a wide range of agro-climatic regions under several production systems that can be grown for providing food, beverages, and other necessities to millions of smallholder farmers (Fikadu *et al.,* 2002). In Ethiopia, barley is grown mainly as a low input staple food crop in the higher altitudes, on steep slopes, eroded lands or in moisture stress areas. It is mainly the major cereal crop grown by subsistence farmers in the highlands above 1800 meters above sea level **(**masl) under rain fed conditions with minimum or no external inputs (Chilot *et al.,* 2002). Barley is cultivated in almost all parts of the country but Shewa, Arsi, Gojam, Gonder producing regions accounting for more than 85% of the country's total production (CSA, 2013).

Bure district has suitable agro ecology for food barley productions. Its grain is used for the preparation of different foodstuffs, such as *Injera, Kolo*, and local alcoholic drinks, such as *Tela*. The straw is also used as animal feed, especially during the dry season (Asresie *et al.,* 2015). However, the productivity of the crop has been consistently much lower than its potential production due to lack of advanced agronomic management practice. Among the factors responsible for low crop yield are, delay in sowing, traditional sowing methods, low seed rate, improved seed varieties and improper row spacing are-very important (ATA, 2015). Appropriate agronomic practice play important role in boosting yield of crops because it influences solar radiation interception, total sunshine reception, nutrient uptake, rate of photosynthesis and other physiological phenomena and ultimately affects the growth and development of plant production (Faisul *et al*., 2013).

The increased advanced agronomical practices like using certified seed of improved varieties, optimum seed rate, timely sowing, proper row spacing may be helpful to increase and improve the yield of barley crop. In the Amhara Region the recommended row spacing for barley is 30 cm with a seed rate of 80-90 kg/ha (ARAB, 2014). While the recent study by CASCAPE in the area used 20 cm row spacing with a seed rate of 100kg/ha (Asresie *et al.,* 2015). Almost all farmers in Bure district sow only one type of barley which is a two rowed variety within appropriate agronomic practice like optimum row spacing and lack of adaption of improved food barley varieties. Besides most farmers used broad casting and didn't accept the recommended row spacing. Despite the potential area for barley, production decreased time to time and the farmers have shifted to other cereal crops mainly maize and wheat (Bure Agricultural Development Office, 2014).

Lack of improved varieties and inappropriate row spacing is a serious constraint in Bure district as far as food barley production concerned. It is important to evaluate the agro-morphological traits in relation to yield and yield components of the improved varieties. However, limited research has been done to evaluate different row spacing on barley varieties in the study area (Asresie *et al*, 2015). So this study is a paramount influence to introduce the improved food barley varieties with the appropriate inter row spacing so as to increase the production and productivity of food barley in Bure district. Therefore, this study was initiated with the following objectives:- To evaluate the effects of different row spacing and variety on agro-morphological traits and to determine the optimum row spacing for maximum productivity of different food barley.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study was conducted at Wanegedam kebele in Bure district, West Gojam zone, in Amhara Regional State, North-western Ethiopia during 2016/17 main cropping season. The area is located 411 kilometers North-west of Addis Ababa and 148 km from Bahir Dar, which is the capital of the Amhara Regional State. The site is situated at 10°42.7' N latitude and 37°5.6' E longitude with an altitude 2600 meters above sea level. The minimum and maximum annual temperatures of the area is 17^0C and 25^0C respectively, while, the minimum and the maximum annual rainfall is 1386 mm and 1750 mm respectively and the dominant soil type of the area was red brown clay (nitosol) (IPMS, 2007).

2.2. Soil sampling and analysis

Soil samples were collected at 0-30 cm soil depth from 12 representative spots of the gross experimental plot before sowing using diagonal sampling method and one composite sample was prepared by mixing them for proper soil characterization. The prepared composite sample for analysis was air- dried as well as grinded to pass through a 2mm sieve in Debre Markos Soil Laboratory and used for the analysis and determination of soil pH, Soil texture, available P, Organic carbon content, cation exchange capacity (CEC), exchangeable Na^+,K^+ and total N were carried out.

2.3. Experimental Materials

Three food barley varieties namely: Abay, Setegn and HB 1307 were used as test crops that were obtained from Adet Agricultural Research Center Urea and NPS were used for the sources of N and phosphors, respectively.

2.4. Treatments and Experimental design

The experiment consisted of 12 treatment combination of four row spacing (20,25,30 and 35 cm) and three food barely varieties (Abay, Setegn and HB 1307). The experiment was laid out in randomized complete block design with factorial arrangement with three replications.

The gross plot sizes were 1.8 m x 3 m (5.4 m^2) but it had different numbers of rows, which was contains 9 rows for 20 cm, 7 rows for 25 cm, 6 rows for 30 cm , and 5 rows for 35 cm inter-row spacing's. The net plot size (harvestable area) were used by excluding the two border rows on both sides of each plots and avoid possible border effects of 0.5 m row length at both ends of the rows. Thus, the net plot sizes were 2 m x 1.2 m for the 20cm inter row spacing, 2 m x 1.05 m for the 25 cm inter row spacing, 2 m x 0.9 m for the 30 cm, and 2 m x 0.75 m inter- row spacing. The space between plots and between blocks was 50 cm and 100 cm in each block, respectively. Field layouts were employed and the treatments allotted randomly to each plot.

2.5. Experimental setup

The land was prepared three times using oxen driven local plow (Maresha) before sowing the food barley varieties. Accordingly, the field was ploughed three times; the last ploughing was used for seed covering in accordance with the specifications of the design and field layout.

The seeds varieties were sown under 4 different inter-row spacing (20, 25, 30 and 35 cm) in the experimental site with 100kg NPS and 100kg Urea/N/ per ha. It was applied 100kg NPS with 33kg Urea per ha at sowing time and the remaining 67kg Urea per ha was applied at topdressing during tillering time. Seed was drilled at the recommended seed rate of 85 kg/ha and was lightly covered by hand at the time of sowing.

Weeding was done at early tillering, maximum tillering and booting stages of growth in three times. Harvesting was done manually when the crop reached to harvest maturity. Finally, the total biomass was harvested from the net plots then dried and threshed**.**

2.6. Data Collection and measurements

The necessary data were collected from central 9 rows of 20 cm, 7 rows of 25 cm, 6 rows of 30 cm and 5 rows of 35 cm row spacing. Days to 50% panicle emergence , days to 90% physiological maturity, plant height , panicle length(cm) , spike length (cm),number of effective tillers, spike number,number of kernel number per spike,thousand-kernel weight (g,biomass yield (kg ha^{-1}), grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index (%)data were taken.

2.7. Statistical data Analysis

Data were subjected to analysis of variances (ANOVA) procedures using the general linear model (GLM) procedure SAS version 9.2(SAS Institute, 2003). Mean separation could be undertaken by Duncan's Multiple Range Test (DMRT) at 5% level of probability. Correlation analyses were also carried out by SAS version 9.2 simple correlation coefficients between yields and yield components

3. RESULTS AND DISCUSION

3.1. Phenological Parameters

3.1.1. Days to heading

Days to 50% heading was significantly ($P < 0.01$) influenced by the main effect of variety. Inter row spacing significantly ($p < 0.05$) influenced days to 50 % heading while their interaction was found to be not significant. Days to 50 % heading delayed significantly in response to increasing inter row spacing. The day to 50% heading was earlier at closer inter row spacing of 20 cm (68.4 days), 25 cm (69.0 days) than 30 cm (69.5 days) and 35 cm (70.9 days) inter row spacing. However, it was statically in parity with the time of heading obtained in response to the spacing of 20, 25 and 30 cm (Table 2).

The main effect inter row spacing was more explanatory when comparing early and late heading of varieties this could be due to competition of plants for resources, due to reduced rate of photosynthesis because of the competition of plants for light, space, nutrients and water under closer spacing and higher planting density in narrow spacing. Results in early number of productive tillers per plant and in turn hastens heading time. When the number of productive tillers per plant was small, the heading time was early by one day, whereas more days were required when it was large productive tillers per plant (Hoshikawa, 1975). Gorgy (2010) reported one day earlier head emergence in plots with 15 cm than with 25 cm row spacing. In closer inter row spacing that might have led the plants to suffer from nutrients high competition, resulting in earlier heading to escape the stressful condition instead of having prolonged vegetative growth and biomass accumulation.

This result was in agreement with that of Law-Ogbomo and Egharevba (2009) who reported that days to flowering was prolonged in plants grown in wider inter row spacing. Yordanos (2013) also reported that day to heading in rice significantly delayed with the increase in inter row spacing. This might be attributed to that closely spaced plants use resources faster and growth rate hastened as described by Langham (2007) where at the same moisture and fertility, high populations will use up the resources sooner and will go through the whole development faster from the mid bloom to the late dry down stage (Abdi, 2013).

Variety setegn was heading significantly earlier (65.4days) than HB1307 (70.5 days) and Abay (72.5days), respectively (Table 2). The variation of heading among food barley varieties might be due to their genetic differences. Seteng variety was found to be the earliest which heading was earlier by 6.1 and 8.1 days than varieties HB1307 and Abay, respectively. This result is also in agreement with that of Muluken and Jemal (2011) who reported that variety Setegn showed earlier heading than HB1307 and Abay varieties. However, the difference in number of days to attain 50% heading might be in this experiment and as reported earlier might also be due to the difference in environmental conditions prevailing at the locations.

3.1.2. Days to physiological maturity

The main effects of row spacing and varieties were highly significant ($P<0.01$) on 90% physiological maturity. However, their interaction did not show significant effect on days to 90% physiological maturity. It was significantly increased with an increase in inter-row spacing for all varieties. The narrowest inter row spacing (20 cm) have taken 97.89 days to attain 90% physiological maturity and the wider (35 cm) inter row spacing have taken 101.2 days and others which was 99.2 and 100 days for 25 and 30 cm row spacing, respectively.

However, it was statistically in parity with the time of physiological maturity obtained in response to the spacing of 20 and 25 cm and 30 and 35 cm (Table 2). This could be due to the presence of intense inter plant competition at the closer row spacing that might have led to depletion of the available nutrient and as a result plants tended to mature earlier. It might be also due to the genetic constitution of varieties and weak competition for resources among the population that resulted plants tend to mature lately in wider inter-row spacing.

This result confirms the finding of Bakht *et al.* (2007) who found that row spacing had a significant ($p < 0.05$) effect on days to maturity. The current finding is in agreement with the work of Tesfaye *et al*. (2012) who concluded that closer inter row spacing (increasing plants density) shortened days to physiological maturity. Tesfalegn (2015) also reported that increase in row spacing, the time to maturity also increased due to the less competition of plants for growth resources at increased row spacing which prolonged the period of vegetative growth while the reduced spacing between plants may exert competition for different growth factors that forced plants to mature earlier.

The findings of this study suggests that under moisture stress condition such as mid to end of September, HB1307 and Abay varieties were stayed green however, Setegn variety had medium grain filling period. Seteng matured significantly (87.4 days) earlier than HB1307 (104.75 days) and Abay about 106.58 days (Table 2). The variation of maturity among food barley varieties might be due to their genetic differences, the agronomic practice and environmental factors. Setegn variety was found to be the earliest that was matured 17.33 days earlier than HB1307 and 19.16 days earlier than Abay variety. Abay and HB1307 are late and medium maturing varieties, respectively. The difference in number of days to attain maturity is due to the genetic difference among varieties (Wosen *et al*., 2015). The same findings were in line with the results of Sohail *et al.* (2014) who conclude that mean values for days to maturity were significantly different among cultivars.

3.2. Growth parameters

3.2.1. Plant height

The findings revealed that plant height was significantly ($P<0.01$) affected by the main effect of row spacing and varieties but their interaction effect was not significant. The inter row spacing of 35 cm resulted in significantly higher plant height (103.58 cm) than 20 and 25 cm inter row spacing. However, statistically no significant difference existed between the plants height under 20 and 25 cm as well as between 25 and 30 cm and 30 and 35 cm row spacing (Table 2). This increment in plant height at wider row spacing might be due to less competition of plants for nutrients, moisture, space and light providing better environment for growth and development of crop.

Similarly, Tesfalegn (2015) explained that the increased plant height at wider row spacing might be due to the change in growth of plants with relatively less competition for growth factors such as mineral nutrients, solar radiation and soil moisture. Mahato *et al.* (2007) reported that maximum plant height was obtained with wider spacing as compared to closer spacing. This results is in agreement with the finding of Shah *et al.* (2014) and Alam *et al*. (2012) who reported that the mean values for maximum plant height was observed (95.55 cm) under wider (30 cm) row spacing than under 15 and 22 cm rows in wheat verities. In contrast to this finding, Kandil *et al.* (2010) reported that narrow inter row spacing produced the tallest plants. The increase in plant height with the narrow hill space might be due to the role of shading in increasing cells elongation and hence increasing plant height**.**

Variety Setegn attained maximum height (103.88 cm) which was significantly different from varieties Abay and HB 1307 which have the height of 100.5 and 98.31 cm, respectively. Whereas statistically no significant differences in plant height existed with varieties Abay and HB1307 (Table 2). Plant height reflects the growth behavior of a crop. Plant height among the varieties could be due to the difference in their genetic makeup that was differently influenced by the environment. Similarly, Shah *et al.* (2014) indicated that the differences in plant height could be due the genetic make-up of varieties. Yemane *et al*. (2014) and *Hussain et al. (2014)* reported that the presence of significant differences among crop cultivars in plant height due to the genetic characteristics, soil nutrients status and environmental condition under which it developed influenced on plant height.

3.2.2. Spike length

Statistical analysis result revealed that main and interaction effects of inter-row spacing and variety were significant ($P< 0.05$) on spike length of food barley varieties. The interaction of 30 cm inter row spacing with variety Abay was showed a longest spike length (9.46 cm) but this variety (Abay) statically similar to the widest row spacing (35 cm) which is 9.3 cm spike length. The shortest (7.01cm) spike length was recorded on variety HB1307 within 20 cm inter- row spacing. However, the other inter row spacing 25, 30,and 35 cm were showed that statically in parity with the shortest spike length on the interaction effects of this variety (HB1307) (Table 1). This study showed that as inter row spacing increased, the spike length was also increased. This could be due to the availability of ample resources required by the barley crop for growth and development and there is presence of more free spaces between plants that are used to avoid competition between plants in the wide inter row spacing rather than the narrowest row spacing. This could have been reflects in lower rates of photosynthesis and growth of those plants, which was expressed in noticeable decrease in spike length in the narrow row spacing.

Table 1. Interaction effect of inter- row spacing and variety on spike length (cm) of food barley at Bure, north-western Ethiopia in 2016/17 main cropping season.

Row spacing(cm)	Varieties V1	V2	V3	Row spacing mean
20	9.06^{ab}	7.01^{e}	8.20^{d}	8.08^{c}
25	8.68^{bc}	7.02^{e}	8.82^{bc}	8.17^{bc}
30	9.46^{a}	7.21^{e}	8.50^{cd}	8.39^{ab}
35	9.30^{a}	7.26^{e}	8.78^{bc}	8.45^{a}
Varieties mean	9.13^{a}	7.13^{c}	8.58^{b}	8.27
	VAR	RS	VAR*RS	
LCR	0.2	0.23	0.4	
CV (%)			2.87	

Means within a column followed by the same letter(s) are not significantly different at P = 0.05 according to Duncan's Multiple Range Test; CV (%) = Coefficient of variation in percent; LCR = Least critical range; *V1= Abay variety; V2= HB 1307 variety; V3=Setegn variety*; VAR = Variety; RS = Row spacing.

However, the varietal difference might be due to the spike length is governed by genetic makeup of the genotype and the environmental effects. Similar result also in agreement with Shahzad *et al.* (2007) who reported that due to the spacing among varieties increased the inter plant competition for light and other nutrients decreased and the genetic makeup of the varieties intercepted sufficient sunlight and nutrients that enhanced the long growth of the spike on wheat crop. Wosene *et al.* (2015) reported that variety Abay had a white seed with long spike. Shah *et al*. (2014) also reported that spike length increased with increasing row in different genotypic of wheat varieties. This result was also in line with the finding of other researchers like Hussain *et al*. (2014) who concluded as there was a positive correlation between spike length and row spacing. However, this finding contradicts with the result of other study in which there was no significant effect of row spacing and row direction on spike length of wheat (Pandey *et al.,* 2013*).*

3.3. Yield and Yield Components

3.3.1. Number of Effective tiller

The analysis of variance showed that there were significant (P<0.01) differences in the number of effective tillers due to the main effects of row spacing and varieties. The interaction between row spacing and varieties was not significant.

Increasing row spacing from 20 to 35 cm increased the number of effective tillers. However, numbers of effective tillers was significantly higher at 35 cm row spacing than with 20 cm row spacing. However, no significant differences were observed between at 25 and 30 cm row spacing. The increase in the number of effective tillers per meter with row length of 20 and 35 cm row spacing were 36 and 51.2 plants/meter, respectively. In the wider row spacing, the more vigorous plants, with particularly higher tillering ability might have produced more photosynthetic than the less vigorous plants with the closer spacing. Moreover, 20 cm row spacing resulted in significantly higher plant population per unit area than other row spacing, which might have caused stiff inter-row competition that, might have led to lesser number of effective tillers per meter row length.

The present study was in agreement with the finding of Yordanos (2013) who reported that the effect of spacing was pronounced in number of effective tiller this may be more space and nutrients available for the individual plant under wider spacing. As a consequence, significant variation in the number of effective tillers per meter was observed due to the varied row spacing. The results are in conformity with Hai-xin *et al.* (2012) who reported that the percentage of productive tiller of cereal variety increased gradually and reached 87.7% when row spacing was 33 cm and Shah *et al*. (2014) who recommended that tillers per unit area increase with increase in row spacing in wheat and barley.

The present study showed that significant differences were found in number of tillers per meter of row spacing in all food barley varieties. The mean value for varieties showed that maximum effective tillers per one meter row (47.58 plants/meter length) were observed in variety HB1307, while minimum numbers of effective tillers per meter (37.92) for Abay varieties. However, there was no statistically difference between HB1307 and Setegn varieties. This finding might be due to the genetic difference of between the varieties.

So it can be concluded that effective tiller number is a genetic characters of food barley varieties, which is highly influenced by agronomic practices like inter-row spacing. Because, the number of effective tillers per unit area increased in wider rows, due to less competition for and efficient utilization of resources. Similar results reported by Shah *et al*. (2014) and Muluken and Jemal (2011) who reported that the tillering numbers of different between varieties in wheat and barley were due to the difference genetic makeup and the environmental factors. The research result of Nizamani *et al.* (2014) in wheat varieties also showed that significant differences were found in number of tillers m^2 at different inter-row spacing.

3.3.2. Spike number

The result of this study revealed that both variety and inter-row spacing had significant ($P < 0.01$) effect on spike number per meter. However, the interaction effect to this parameter wasn't significant.

Increasing row spacing from 20 cm to 35 cm increased the number of effective spikes. However, no statistically significant differences were observed between 25 and 30 cm row spacing. The number of spike per meter with 20 and 35 cm was 38 and 52.4 spike numbers, respectively. In the wider row spacing, the more vigorous plants, with particularly higher tillering ability might have produced more photosynthesis than the less vigorous plants with the closer spacing which might have caused stiff inter-row competition that, might have led to lesser number of effective spike number per one meter row length. This result agrees with the findings of Raziya (2015) and Rajeev (2007) who reported that the effect of spacing was pronounced in number of effective tiller and more number of spikes. This may be differing to more space and nutrients available for the individual plant under wider spacing.

The varieties were significantly differed for spike number per meter. The highest (48.75) spike number per one meter length was produced by the variety HB1307 and followed by variety Seteng 46.67 spike number per meter row length. However, these varieties had no statistically significant difference for spike number per row length. The least number of spikes which was 39.08 per one meter row length was produced for variety Abay (Table 2). This might be due to the less number of effective tillers and the genotypic different between the varieties. This finding is in agreement with the observations of Germa (2013) who stated that different varieties had highly significantly affected spike number per meter length per square of barley. Inamullah *et al.* (2006) also observed significant differences in spike per meter among different cereal varieties.

3.3.3. Number of kernels per spike

Number of Kernels per spike was significantly ($P < 0.01$) affected by the main effects of row spacing and varieties whereas their interaction had no significant effect on this parameter. The results showed that wider row spacing (35 cm) led to significantly higher number of kernels per spike than other row spacing. These results might be due to at a wider spacing more availability of growth resources, i.e. nutrients, moisture, space and light that might have resulted in increase in chlorophyll which resulted in higher photosynthetic rate and ultimately availability of more photosynthate for sink formation during grain formation.

The widely spaced plants was more effective in mobilizing photosynthesis for grain filling compared to closely spaced plants (Hasanuzzaman *et al.,* 2009) and Yordnos (2013). The same result in agreement this also Shah (2014) was reported in numbers of grains per spike increased with increasing row spacing. The result was also in conformity with the findings of Bakht *et al.* (2007) who revealed that row spacing had a significant ($p < 0.05$) effect on number of grains per spike, and Hussain *et al.* (2012) who found that higher number of grains per spike was noted under wider row spacing.

The highest kernel number of per spike (46.37) was produced by variety Abay, followed by HB 1307 (44.7) and Setng (40). This results might be due to the spike length difference among the varieties, Abay a longest spike variety and six rowed but the lest variety (Setegn) even though a long spike variety next to Abay but had un defining rowed variety in the study. Generally, this might be the genotypic and environmental effects. This finding was in agreement with the findings of Wosene *et al*. (2015) who reported that Genotype (G), environment (E) and genotype-by-environment (G x E) interaction affected both kernel per spike and grain yields.

Table 2: The main effects of row spacing and variety on days to 50% heading, days to 90% physiological maturity, plant height (cm), number of effective tiller, spike number of food barley.

	Days to 50% heading	Days to 90% physiological maturity	Plant height (cm)	Number of effective tiller	Spike numbers	Number of kernels per spike
Row Spacing (cm)						
20	68.4^{b}	97.89^{c}	98.7^{c}	36.8^{c}	38.11^{c}	38.67^{d}
25	69.0^{b}	99.10^{bc}	99.7^{bc}	42.4^{b}	43.55^{b}	41.40^{c}
30	69.5^{ab}	99.90^{ab}	105.5^{ac}	44.0^{b}	45.22^{b}	46.01^{b}
35	70.9^{a}	101.30^{a}	103.6^{a}	51.2^{a}	52.44^{a}	48.72^{a}
LCR (0.05)	1.53	1.62	2.64	3.07	3.12	1.5
Varieties						
Abay	72.5^{a}	106.2^{a}	100.5^{b}	37.9^{b}	39.08^{b}	46.37^{a}
HB 1307	70.5^{b}	104.3^{b}	98.3^{b}	47.6^{a}	48.75^{a}	44.74^{b}
Seteng	65.4^{c}	88.0^{c}	103.8^{a}	45.0^{a}	46.67^{a}	40.00^{c}
LCR (0.05)	1.33	1.4	1.4	1.35	2.7	1.3
CV (%)	2.25	1.67	2.68	7.20	7.11	3.53

Means within a column followed by the same letter(s) are not significantly different at P = 0.05 according to Duncan's Multiple Range Test; CV (%) = Coefficient of variation in percent; LCR = Least critical range.

Other researchers also showed that, the differences in number of grains per spike were probably due to variation in genetic potential from variety to variety (Akhatar *et al.,* 2001). From this result, it can be concluded that different values and large number of kernels per spike could be explained primarily by type of sowing, helping to ensure optimal conditions for the development of a large number of spikelet's and florets, on the other hand, creating favorable conditions for flowering and pollination, resulting in higher average values for the number of grains per spike (Knezevic *et al.,* 2012).

3.3.4. Thousand kernel weight

Thousand kernel weights is also an important yield determining component of barley. Analysis of variance indicated that thousand kernel weight was significantly ($P < 0.01$) affected by inter row spacing and varieties. Their interaction had also significant ($P <0.05$) influence on thousand kernel weight. The results showed that with the increase in spacing the thousand kernel weight also increased significantly. The combining effects of variety and row spacing showed that maximum kernel weight (47.9 g) was recorded in Setegn variety under 35 cm row spacing and minimum (29.3g) was recorded in Abay variety under in 20 cm row spacing. However, no significant difference was observed in HB 1307 variety under 20 cm row spacing (Table 3).

Table 3. Interaction effect of inter- row spacing and variety on thousand kernel weight of food barley at Bure, north- western Ethiopia in 2016/17 main cropping season.

Row spacing(cm)	Varieties			Mean of row spacing
	V1	V2	V3	
20	29.30^{h}	29.88^{h}	36.16^{de}	31.78^{d}
25	32.44^{g}	33.39^{fg}	43.42^{c}	36.42^{c}
30	35.27^{ef}	36.04^{de}	45.39^{b}	38.90^{b}
35	37.23^{de}	37.70^{d}	47.90^{a}	40.94^{a}
Mean of varieties	33.56^{b}	34^{b}	43.22^{a}	37.01
	VAR	RS	VAR*RS	
LCR	0.97	1.12	1.94	
CV (%)		3.09		

Means within a column followed by the same letter(s) are not significantly different at P = 0.05 according to Duncan's Multiple Range Test; CV (%) = Coefficient of variation in percent; LCR = Least critical range; V1= Abay variety; V2= HB 1307 variety; V3=Setegn variety VAR = Variety; RS = Row spacing.

The highest thousand kernel weight might be due to efficient utilization of water, nutrients and light due to minimal inter-rows competition and lower plant population. The maximal values for thousand kernel weight were observed may be attributed to an increase assimilate synthesis and translocation to the grain which resulted in higher contents of protein and other food reserves. Alam *et al.* (2012) and Ali *et al.* (2010) also found the same results who obtained increased grain weight at wider row spacing (22.5 cm) in wheat. The maximum thousand kernel weight was recorded on variety Setegn (43.22g) that attributed to their comparatively well-developed bold grains compared to other two varieties.

3.3.5. Biomass yield

The biomass yield was significantly increased with increasing row spacing. Biomass production is the function of various biochemicals, physiological and environmental features. The analysis of variance revealed that the main and interaction effects of inter row spacing and variety showed significant (P<0.05) effect on above ground dry biomass.

The highest significant biomass yield (11864.3 kg/ha) was recorded for variety HB1307 with 35 cm inter row spacing treatment combination. However, this result was not statistically different for other varieties with row spacing of 35 cm. The lowest above ground dry biomass (7985.3 kg/ha) was recorded for variety Abay with 20 cm row spacing (Table 8).Varieties exhibited different biomass yield at low, medium and wider row spacing. Biological yield is highly inclined by crop nutrition and planting distance (Iqbal *et al.,* 2012).The increase in above ground dry biomass in response to increasing (widening) the row spacing might be due to the better environment for growth and development of crop that might have resulted in better plant height, more number of effective tillers and number of grains per spike.

Table 4. Interaction effect of inter- row spacing and variety on biological yield of food barley at Bure, north-western Ethiopia in 2016/main cropping season.

Row spacing(cm)	Varieties			Mean of row spacing
	V1	V2	V3	
20	7985.3[e]	8472.7[e]	8470.0[e]	8309.3[d]
25	9191.3[d]	10072.0[c]	9143.7[d]	9469.0[c]
30	9442.8[d]	10506.0[bc]	10754.5b	10234.5[b]
35	11472.7[a]	11864.3[a]	11664.0[a]	11667.0[a]
Mean of varieties	9523[b]	10228.8[a]	10008[a]	9919.96
	VAR	RS	VAR*RS	
LCR	303.0	349.9	606.1	
CV (%)		3.61		

Means within a column followed by the same letter(s) are not significantly different at P = 0.05 according to Duncan's Multiple Range Test; CV (%) = Coefficient of variation in percent; LCR = Least critical range; *V1= Abay variety; V2= HB 1307 variety; V3=Setegnvariety* VAR = Variety; RS = Row spacing.

These combination different with the varieties might be due to genetic difference of the varieties and the high population density in a row which resulted competition of nearby plants in absorbing light, soil nutrients and moisture. Ali *et al.* (2011) also found that increased biomass yield with wider row spacing due to higher production of tillers in rice crop. However, Chen *et al.* (2008) reported that narrower row spacing produced higher biomass yield than wider row spacing. In agreement with this study, Grima (2013) and Wosen e*t al.* (2015) indicated that variety HB 1307 exhibited high yielding, lodging resistance and resistant to leaf disease with good biological yield. The present finding was in agreement with the finding of Hussain *et al.* (2014) who reported that grain yield was significantly influenced by the interaction of different row spacing with different crop varieties.

3.3.6. Grain yield

The main and interaction effects of inter- row spacing and variety (P<0.05) showed significant effect on grain yield. Grain yield was increased with increasing row spacing in all varieties. Variety HB 1307 with inter-row spacing of 35cm resulted in highest grain yield (4425.7kg/ha). The lowest grain yield (2971 kg/ha) was recorded for variety Abay with 20 cm row spacing which was statistically similar to the yield obtained for varieties Setegn with 20 cm and Abay at row spacing 25 and 30 cm at the same order. The possible reason might be the numbers of effective tillers per plant, number of grains per spike and kernel weight were the major determinants of final yield. Due to this and other genetic traits variety HB1307 out yielded than the other two varieties (Table 9).

Table 5. Interaction effect of inter row spacing and variety on grain yield of food barley at Bure, north- western Ethiopia in 2016/17 main cropping season.

Row spacing(cm)	Varieties			Mean of row spacing
	V1	V2	V3	
20	2971.1^{f}	3267.3^{de}	3117.0^{ef}	3118.50^{c}
25	3171.7e^{f}	3368.0^{de}	3355.0^{de}	3298.22^{b}
30	3186.0e^{f}	3459.3^{dc}	3266.3^{de}	3303.89^{b}
35	3680.0^{bc}	4425.7^{a}	3858.3^{b}	3988.00^{a}
Mean of varieties	3252.2^{c}	3630.08^{a}	3399.17^{b}	3427.15
	VAR	RS	VAR*RS	
LCR	119.1	137.6	1.94	
CV (%)		4.11		

Means within a column followed by the same letter(s) are not significantly different at P = 0.05 according to Duncan's Multiple Range Test; CV (%) = Coefficient of variation in percent; LCR = Least critical range; V1= Abay variety; V2= HB 1307 variety; V3=Setegn variety VAR = Variety; RS = Row spacing.

On the other side, among the observations it was found that different genotypes show variation in grain yield. So the grain yield and yield relating characters in barley show variation in different degrees and this difference are accompanied by their genetic materials, agronomic practices like spacing and effects of environmental factors (Karim and Jahan, 2013). These results were in line with the finding of Hussain *et al.* (2014) who reported that grain yield was significantly influenced by the interaction of different row spacing and cultivars. In agreement this Girma (2013) also reported that variety HB 1307 resulted in medium plant height, high grain, and long grain filling duration. This result is in line with the investigations of Kemelew (2011) who reported that the high yielding clusters are characterized by long grain filling periods, medium plant height and high thousand kernel weight in Ethiopian barley landraces. The lower plant population also might have effectively utilized the water, nutrients and light. In agreement with this result, Chaturvedi (2004) and Alam *et al.* (2012) reported that the number of tillers per unit area was the most important component of yield.

Therefore, the higher the number of tillers, especially fertile tillers, the more will be the yield. The results of this study was in line with that of Ali *et al.* (2010), Iqbal *et al.* (2010), Kamara *et al.* 2011 and Sultan *et al.* (2012) who reported that yields of cereals increased as the spacing between rows increased because plant populations are normally high in narrow spacing and most panicles are produced on the main Culm rather than on tillers, so that tillering capacity affects grain yield. However, this contradicts with the finding of Pandey *et al.* (2013)who reported as there was no significant ($p < 0.05$) effect of row spacing's on wheat grain yield or the grain yield of wheat was not affected by the row spacing treatment.

3.3.7. Straw yield

The main and interaction effects of row spacing and varieties had significantly ($P< 0.01$) influenced the straw yield. The highest straw yield (11791.3 kg/ha) was obtained from the treatment combination of 35 cm row spacing and variety HB 1307. However, statistically similar with interaction of the two other varieties which was Setegn and Abay with 35 cm inter row spacing. The lowest straw yield (5014 kg/ha) was obtained with 20 cm row spacing with Abay variety (Table 10). The differences among cultivars in straw yield may be contributed through their genetic makeup and efficiency in resource utilization.

Table 6. Interaction effect of inter- row spacing and variety on straw yield of food barley at Bure, north- western Ethiopia in 2016/17 main cropping season.

Row spacing(cm)	Varieties			Mean of row spacing
	V1	V2	V3	
20	5014.2^{f}	8402.3^{e}	84050.0^{e}	7273.9^{d}
25	9117.3^{d}	10000.0^{c}	9079.7^{d}	9399.0^{c}
30	9368.8^{d}	10436.8^{bc}	10687.5^{b}	10164.4^{b}
35	11398.7^{a}	11791.3^{a}	11598.3^{a}	11596.0^{a}
Mean of varieties	8724.8^{b}	10157.6^{a}	9942.6^{a}	9608.34
	VAR	RS	VAR*RS	
LCR	302.4	349.1	604.7	
CV (%)		3.72		

Means within a column followed by the same letter(s) are not significantly different at P = 0.05 according to Duncan's Multiple Range Test; CV (%) = Coefficient of variation in percent; LCR = Least critical range; V1= Abay variety; V2= HB 1307 variety; V3=Setegn variety VAR = Variety; RS = Row spacing.

Row spacing might have influenced vegetative growth in terms of plant height and number of tillers per meter row length (effective and non-effective tillers) which resulted in increased straw yield with the interaction of different genotypic characteristics of the food barley varieties. In agreement with this finding Kalpana *et al.*

(2014) more number of tillers $m^2$and higher leaf area index might be responsible for influencing higher straw yield. Corroborating with the results of this study, Shah *et al.* (2014) reported that the main effect of cereal varieties and row spacing significantly affected straw yield. Similar trend of straw yield was also reported by Sultana *et al.* (2012) and Hai-xin *et al*. (2012).The same findings also presented on wheat, by Bakht *et al.* (2007) who indicated that row spacing had a significant ($p < 0.05$) effect on straw yield of wheat, and Ali *et al*. (2010) who reported that the effect of row spacing was significant ($p < 0.05$) on straw yield of wheat during all the study years.

3.3.8. Harvest index

The potential of barley was determined by the harvest index which is one of an important yield component. The current result revealed that the main and interaction effects of inter row spacing and variety had significant ($p<0.05$) effect on harvest index of barley. The investigation statistical analysis result revealed that the maximum harvest index (38.56%) was achieved for the treatment combination of 35 cm inter-row spacing with variety HB 1307 but which was statistically at par with the harvest index obtained with variety Abay under 35cm and variety Setegn with the treatment combination of 25 cm inter row spacing. The lowest harvest index (31.02%) was recorded with the combination of 30 cm row spacing with variety Setegn (Table 7). These differences among varieties for harvest index might be due to their genetic constitution. This finding was supported by Hussain *et al*. (2014) who elucidated that harvest index was significantly influenced by different row spacing, cultivars and their interaction.

Variety HB1307 significantly produced the highest harvest index of all the other two varieties. As a result variety HB 1307 was found to be the most efficient in converting assimilates in to grain yield. The ability of a cultivar to convert the dry matter in to economic yield is indicated by its harvest index. This finding was supported by (Iqbal *et al.,* 2012) who were reported that the higher the harvest index value, the greater the physiological potential of the crop for converting dry matter to grain yield. An increased in plant height reduced harvest index. Reduction in harvest index for plant height above 70-100 cm has been reported by Royo *et al*. (2007). Sintayehu *et al.* (2003) and White and Wilson (2006) also reported the same results with different barley and wheat varieties, respectively. The fact that variety HB 1307 resulted in high harvest index revealed its capacity to efficiently distribute the dry matter produced to sink organ compared to the other varieties. In the row spacing of 20cm and 30cm row spacing the highest (32.93%) and (36.76%) harvest index was recorded in treatment combinations of variety HB 1307, respectively. but in 25 cm inter row spacing the maximum (34.55%) showed in combination with variety setegn.

Table 7. Interaction effect of inter- row spacing and variety on harvest index of food barley Bure, north- western Ethiopia in 2016/17 main cropping season.

Row spacing(cm)	Varieties			Mean of row spacing
	V1	V2	V3	
20	32.06^{dc}	32.93^{bcd}	31.90^{dc}	33.57^{c}
25	34.55^{b}	33.43b^{c}	36.72^{a}	34.90^{b}
30	33.74^{bc}	36.76^{a}	31.02^{d}	32.56^{c}
35	37.20^{a}	38.56^{a}	36.93^{a}	37.56^{a}
Mean of varieties	34.39^{ab}	35.42^{a}	34.14^{b}	34.65
	VAR	RS	VAR*RS	
LCR	1.04	1.2	1.94	
CV (%)		3.55		

Means within a column followed by the same letter(s) are not significantly different at P = 0.05 according to Duncan's Multiple Range Test; CV (%) = Coefficient of variation in percent; LCR = Least critical range; V1= Abay variety; V2= HB 1307 variety; V3=Setegn variety VAR = Variety; RS = Row spacing.

Best genetic makeup of varieties along with wider row spacing observed superior (37.56%) harvest index as increased dry matter portioning is a fundamental response of wider row spacing in barley crop (Hussain *et al*., 2014), since harvest index is an indicator of dry matter partitioning towards the reproductive organs. Therefore, this experiment result was in agreement with the finding of Pandey *et al.* (2013) who approved that in wheat, sown at the wider row spacing (25 cm) had significant ($p < 0.05$) harvest index than that of narrow row spacing's (15 & 20 cm). Harvest index as a quantitative trait is an indicator of plant efficiency to distribute dry matter in grain yield (Shahryari and Mollasadeghi, 2011). In contrasts this finding Mondal *et al*. (2012) who found that the highest harvest index was observed in 20 cm row spacing in rice crop, but statistically similar with 25 cm row spacing. Hussain *et al.* (2012) who found that higher harvest index was reported in 20 cm row spacing, but statistically similar with 25 cm row spacing in wheat and barley crop.

3.4. Correlation Analysis

Grain yield was highly significant and positive correlated with biological yield, effective tiller numbers, harvest index and spike number and significantly differ with thousand kernel weight and spike length. These indicated that the yield increase is attributed to an increase in effective tiller number, spike length, spike number, number of kernels per spike, thousand kernel weight, biomass yield and harvest index. These characters contributed positively towards total variation in yield, and should be considered when selecting cultivars for highest grain yield. Peymaninia *et al.* (2012) reported that increasing number of seed per spike had an effect on the speed of photosynthesis, therefore, the potential produce of photosynthesis material increase and then yield increased.

4. CONCLUSIONS

The result of this study revealed that the main effect of inter row spacing and variety showed significant effect on the phenological parameters, growth parameters and yield and yield components. This effect on days to heading and days to physiological maturity were delayed in response to increasing (widening) the row spacing from 20 to 35 cm. The variety Setegn was earlier (65.4 days) in heading and maturing time (88 days) than variety HB1307 (70.5 and 104.3 days) and Abay (72.5 and 106.2 days), respectively. Setegn was also the tallest (103.8 cm) varieties as compared to HB1307 (98.3 cm) and Abay (100.5 cm) varieties. In conclusion, the results from the study indicated that inter row spacing and barley varieties had a significant influence on the phenology, growth, yield and yield components. Therefore, substantial increases in yield-related traits under 35cm row spacing in variety HB 1307 (medium stature and high tillering was recorded highest productivity (4.4 ton/ha) and the lowest productivity was obtained from variety Abay (3.6 ton/ha).Therefore, verity HB1307within 35 cm inter row spacing considered as the most productive that shall be used for maximize production of food barley under the study area. However, to this is one season experiment at one location, the experiment has to be repeated over locations and seasons with inclusion of more improved varieties to reach at a more reliable and full conclusion.

5. REFERENCES

Abdi Farah,2013.Effect of Inter and Intra Row Spacings on Yield and Yield Components of Sesame (*Sesamumindicum*L.) under Irrigation at Gode, Eastern Ethiopia.M.Sc Thesis, Haramaya University, Haramaya, Ethiopia.

ATA (Agricultural Transformation Agency) 2015.Annual report. ATA. Addis Ababa, Ethiopia.

Akhatar M.Z., Khan M.A., Ahmed K. and Alam M. 2001. Evaluation of Wheat (Triticum aestivum L.) varieties for their potential Grain yield under the Agro-ecological conditionsof D.I. Khan. Asian Network for Scientific Information:543-567.

Alam, M.S., M.A. Baki, M.S. Sultan, K.J. Ali and M.S. Islam, 2012.Effect of variety, spacing, and number of seedling per hill on the yield potentials of transplant amanrice.*International Journal of Agronomy and Agricultural Research,* 2(12): 10-15.

Ali, M.; A. Abouzar; B. Saeid; and A. Hashem, 2011.Effect of different levels of nitrogen and plant spacing on yield, yield components and physiological indices in high-yield rice (number 843).*American-Eurasian Journal Agricultural and Environment Science,* 10(5):893 – 900.

Ali, M.A, L. Ali, M. Sattar and M. Ali, 2010. Improvement in wheat (*Triticum aestivum* L.) yield by manipulating seed rate and row spacing in Vehari zone, *Journal of Animal and Plant Sciences,* 20(4): 225-230.

Asresie Hassen, Molla Tafere, Mekonen Tolla, Seferew Dagnew, Abel Ahmed and Alemu Worku, 2015. Best fit Practice Manual forFood barley Production, BDU-CASCAPE working paper 7.

Bakht J., Qamer Z., Mohammad Shafi, Habib Akber, Masood-ur-Rahman, Nazir Ahmad and Javed Khan M.. 2007. Response of different Wheat varieties to various Row Spacing.*Sarhad* J. Agric. Vol. 23, No. 4.

Bakht J., Qamer Z., Mohammad Shafi, Habib Akber, Masood-ur-Rahman, Nazir Ahmad and Javed Khan M.. 2007. Response of different Wheat varieties to various Row Spacing.*Sarhad* J. Agric. Vol. 23, No. 4.

Bayeh Mulat and Grando, S., 2011.Barley researh and development in Ethiopia. Proceedings of the second national barley research and development Review workshop. 28-30 November 2006. HARC, Holetta, Ethiopia.ICARDA, PO Box 5466, Aleppo, Syria.

CSA (Central Statistical Authority) 2014.Agricultural sample survey report. Addis Ababa, Ethiopia.

Chen, C.K., K. Neill, D.Wichman and C. Westcott 2008.Hard Red Spring Wheat Response to Row Spacing, Seeding Rate, and Nitrogen. *Agronomy Journal,* 100:1296-1302.

Chilot Yirga, Alemayehu Fikadu and Woldeyesus Sinebo, 1998.Barley-based farming systems in the highlands of Ethiopia. Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia.

Engels, J. M. M. 2012. Genetic diversity in Ethiopia in relation to altitude. – Genet. Resource.Crop Evol.41:67 – 73.

Faisul U.R., Raihana, H and Bhat, M. I., 2013. Agronomic evaluation of rice (*Oryza sativa* L.) for plant spacing and seedlings per hill under temperate conditions. *African Journal Agriculture Research,* 8 (37): 4650-4653.

Girma Gemedi,2013. Influence of Row Spacing and Nitrogen Rates on Yield and Yield Components of Direct-Sown Irrigated Rice at Gode, South-eastern Ethiopia,An M Sc Thesis, Haramaya University, Haramaya, Ethiopia.

Hai-xin, Z., W. Xiao-xue, G. Zhen-hua, H. Xiao-qun and L. Hua-long, 2012. Effects of row spacing on canopy structure and yield in different plant type rice cultivars, *Journal of Northeast Agricultural University.*19(4):11-19.

Hasanuzzaman, M., K., Nahar, T.S. Roy, M.L. Rahman, M.Z. Hossain and J.U. Ahmed, 2009. Tiller Dynamics and Dry Matter Production of Transplanted Rice as Affected by Plant Spacing and Number of Seedling per Hill. *Academic Journal of Plant Sciences,* 2 (3): 162-168.

Hussain, M., Z. Mehmood, M. B. Khan, S. Farooq, D.J. Lee and M. Farooq, 2014. Narrow Row Spacing Ensures Higher Productivity of Low Tillering Wheat Cultivars. *International Journal of Agriculture and Biology,* 14:413 – 418.

Inamullah, H. A., F. Mohammad, S.U. Din, G. Hassan and R. Gul. 2006. Diallel analysis of the inheritance pattern of agronomic traits of bread wheat. *Pak. J. Bot.,* 38 (4): 1169-1175.

International Center for Agricultural Research in the Dry Areas (ICARDA), 2013. www.icarda.org/publications/Donors/Ethiopia/G-Barley.htm

IPMS, 2007. Bure Pilot Learning District Diagnosis and Program Design.Unpublished.

Iqbal J. Hayat K. and Hussain S. 2012. Effects of Seeding rates and nitrogen level on yield and yield components of Wheat. *Pakistan Journal of Nutrition* 11 (7):629-634.

Iqbal, N., N. Akbar, M. Ali, M. Sattar and L. Ali, 2010.Effect of seed rate and row spacing on yield and yield components of wheat (*Triticum aestivum* L.).*Journal Agricultural Research*, 48(2): 151-156.

Kalpana .A, p.Prusty and S.K. Mukhopadhyay,2014.Performance of wheat genotypes under different row spacing in New Alluvial Zone of West Bengal.*Journal of Crop and Weed,* 10(2):480-483(2014)

Kamara, A.Y., D. Chikoye, F. Ekeleme, and L.O. Omoigui, 2011. Influence of nitrogen fertilization on yield and yield components of rain-fed lowland NERICA® rice in the northern Guinea savanna of Nigeria. *African Journal of Agricultural Research, 6*(13): 3092-3097. *http://www.academicjournals.org/AJAR*

Kandil, A. A., S. E. El-Kalla, A. T. Badawi and O. M. El-Shayb, 2010.Effect of hill spacing, nitrogen levels and harvest date on rice productivity and grain quality.*Crop and Environment,* 1(1):22- 26.

Karim MD. H., and Jahan M. A. 2013. Comparative study of yield and yield contributing traits of different genotypes in Bread Wheat.ARPN Journal of Agricultural and Biological Science.*Volume 8, NO. 2.*

Knezevic D., Zecevic V.Stamen kovic S., Atanasijevic S. and Milosevic B. 2012.Variability of number of kernels per spike in Wheat cultivars (*Triticum aestivum* L.).*Journal of Central European Agriculture.13 (3), p.608-614.*

Langham, D.R., 2007. Issues in New Crops and New uses. J. Janic and A. Whipkey (eds.) ASHS Press, Elexandaria, VA.

Law-Ogbomo, K.E. and R.K.A. Egharevba, 2009.Effect of planting density and NPK fertilizer application on yield and yield components of Tomato.*World Journal of Agricultural Science,* 5: 152-158.

Mahato, P., S.K. Gunri, K. Chanda and M. Ghosh, 2007.Effect of varying levels of fertilizer and spacing on medium duration rice (*Oryza sativa* L.) in Tarai Zone of West Bengal.*Karnataka Journal of Agricultural Science,* 20(2): 363-365.

Mondal, M.M.A, M.I.K. Rana, M.H. Imam and J. Sultana, 2012. Determination of row spacing based on morphological characters in Aus rice. *International Journal of Sustainable Crop Production,* 7(1):34-37.

Muluken Bantayehu and Jemal Esmae 2011.Achievements in food barley breeding research in the early production systems of northwest Ethiopia.ARARI, Adet Agricultural Research Centre (AARC), P.O. Box 08, Bahir Dar, Ethiopia

Nizamani G. S., Khan I. A., Khatri A., Siddiqui M. A., Nizamani M. R. and Khaskheli M. I. 2014. Influence of different row spacing on agronomic traits in different Wheat varieties.*International Journal of Development Research Vol*. 4, Issue, 11, pp. 2207-

Pandey B. P., Basnet K. B., Bhatta M. R., Sah S. K., Thapa R. B., Kandel T. P. 2013. Effect of row spacing and direction of sowing on yield and yield attributing characters of wheat cultivated in Western Chitwan, Nepal. *J. Agricultural Sciences Vol.*4, No.7, 309-316.

Peymaninia Y., Valizadeh M., Shahryari R., Ahmadizadeh M. and Habibpour M. 2012.Relationship among Morpho-physiological Traits in Bread Wheat against Drought Stress at Presence of a Leonardite Derived Humic Fertilizer under Greenhouse Condition.*International Research Journal of Applied and Basic Sciences.* Vol., 3 (4), 822-830

Royo, C., A.F.´ lvaro, V. Martos, A. Ramdani, J. Isidro, D. Villegas and Garcia Del Moral, L. F., 2007. Genetic changes in durum wheat yield components and associated traits in Italy and Spain during the 20th century. Euphytica155: 259–270.

Shah Nizamani, Imtiaz Ahmed Khan, AbdulaKhatri, Muhammad Aquil ,2014.Influence ofDifferenet Row Spacing in Agronomical Traits in Diffrenent Wheat Varieties.*International Journal of Development Research Vol*. 4, Issue, 11, pp. 2207-2211.

Shahryari, R. and V. Mollasadeghi, 2011.Correalation study of some traits affecting yield and yield components of wheat genotypes interms of normal irrigation and end drought stress.*Advances in Environmental Biology*. 5(3): 523-527.

Shahzad, M.A., Wasi-ud-Din, Sahi, S.T., Khan, M.M., Ehsanullah and Ahmad M. 2007.Effect of sowing dates and seed treatment on grain yield and quality of wheat.*Pakistan Journal of Agriculture Science,* 44: 581-583.

Sintayehu Debebe, 2003.Variability and associations among yield and yield related traits in barley. An Msc Thesis Presented to the School of Graduate Studies of Alemaya University.

Sohail M., Hussain I., Riaz-ud-din, Tanveer S. K., Qamar M. and Abbas S. H. 2014. Physio-Agronomic traits evaluation of wheat genotypes for adaptability under rainfed conditions. *Sarhad J. Agric*. Vol. 30, No.2

Sultana, M.R., M.M. Rahman and M.H. Rahman, 2012.Effect of row and hill spacing on the yield performance of boro rice (cv. BRRI dhan45) under aerobic system of cultivation.*Journal of Bangladesh Agricultural University,* 10(1): 39 – 42.

Tesfalegn Jambo, 2015. Response of Onion (*Allium cepa*L.) Varieties to Intra-row Spacing at Kobo, Northern Ethiopia.An M Sc Thesis, Haramaya University, Haramaya, Ethiopia.

Tesfaye Getachew, Derbew Belay and Solomon Tulu, 2012.Yield and growth parameters of potato (*Solanumtuberosum*L.) as influenced by intra row spacing and time of earthingup. *International Journal of Agricultural Research,* Pp 1-11. *ISSN 1816-4897 / DOI:10.3923/ijar.*

White, E.M. and F.E.A. Wilson, 2006.Response of grain yield, biomass and harvest index and their rates of genetic progress to nitrogen availability in ten winter wheat varieties.*Irish Journal of Agriculture and Food research.*45:85-101.

Wosene G. Abtew, BerhaneLakew, Bettina I. G. Haussmann1, Karl J. Schmid,2015. Ethiopian barley landraces show higher yield stability and comparable yield to improved varieties in multi-environment field trials. *Journal of Plant Breeding and Crop Science*, Vol. 7(8), pp. 275-291

Yemane Kahsay, Derbew Belew and Fetien Abay. 2014. Effect of intra-row spacing on plant growth and yield of onion varieties (*Allium cepa*L.) at Aksum, Northern Ethiopia. *African Journal of Plant Science.*9(10): 931-940.

Yordanos Ameyu ,2013. Influence of Row Spacing and Nitrogen Rates on Yield and Yield Components of Direct-Sown Irrigated Rice at Gode, South-eastern Ethiopia.An M Sc Thesis, Haramaya University, Haramaya, Ethiopia.