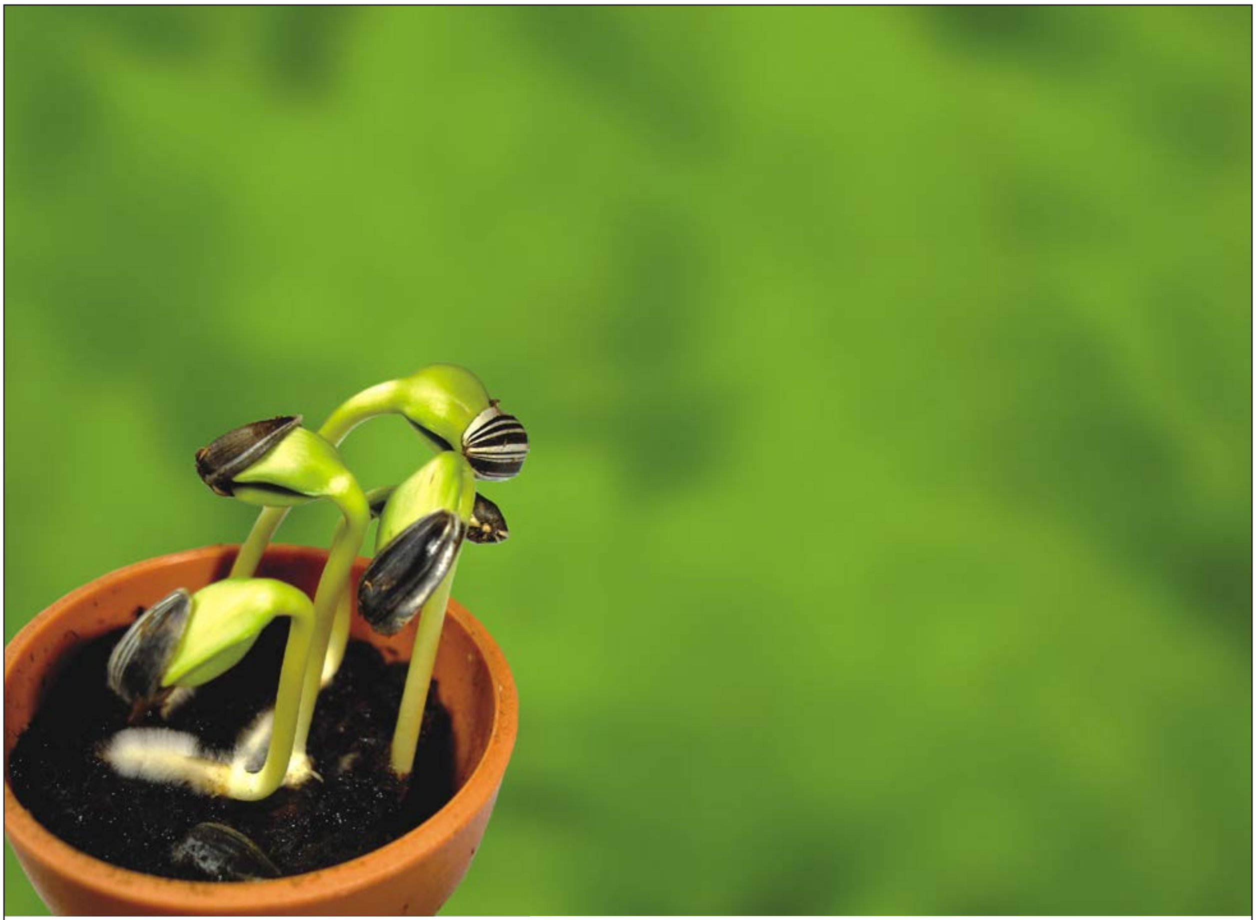

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Selection of Barley Varieties for their Yield Potential at Low Rain Fall Area Based on Both Quantitative and Qualitative Characters North West Tigray, Shire, Ethiopia

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ABSTRACT

Although, Ethiopia is a center of diversity for barley, most of the country's farmer still obtain very low yield due to a combination of genetic, environmental and socio-economic constraints. For this study, a total of ten barley varieties were collected and arranged in randomized complete block design with four replications to select barley varieties for their yield potential at low rain fall area based on both quantitative and qualitative characters North West Tigray, Shire, Ethiopia in 2011 main cropping season at Shire the well foundation Organization FTC. Number of tillering, plant height, days to heading, days to maturity, grain failing period, grain yield, seeds per spike, spike length, biological yield, harvest index and straw yield were evaluated and analyzed by SAS and JMP5 statistical software. Analysis of variance indicates that variations were observed in all agronomic traits which highly influence yield performance. Variety that possessed a maximum plant height, large spike length and high number of seed per spike was produced high grain yield than the other varieties (103.25, 7 cm, 40 seed spike^{-1} and 19.445 q ha^{-1}, respectively). Among the varieties, Biftu (V2) was possessed the highest grain yield (19 q ha^{-1}) both in quality and quantity than other varieties at low rain fall area as compared to other varieties V3 (local) (11.110), V10 (12.500) and V9 (13.195) q ha^{-1}, respectively which were produced smaller grain yield. These data indicates that plant height, spike length and number of seed per spike were the most agronomic traits that affect the grain yield performance of barley than the other traits at low rain fall area. The finding indicates that, improved varieties of barley were produced higher grain yield than farmer variety.

Key words: Agronomic traits, barley varieties, farmer variety, qualitative characters, quantitative characters

INTRODUCTION

Barley (*Hordium vulgare* L.) is recognized as one of the world's most ancient food crop, which is believed to have first domesticated about 10,000 years ago from its wild relatives in the Fertile Crescent of the Near East and center of diversity in Ethiopia. Throughout the history, barley has undergone continuous manipulation in an effort to optimize its use for human consumption and as animal feed. Globally, barley ranks fourth among cereal crops in both yield and acreage, after wheat, rice and maize (Munck, 1992).

With advances in food production and agriculture, major dietary shifts from barley to rice/or wheat have resulted in the decline in barley consumption. With the exception of societies; particularly those relying on traditional, small-scale agricultural systems, in which its use as human food has continued to the present. The world has now "re-discovered" barley as a food grain with desirable nutritional composition including some medicinal properties (Grando and Helena, 2005). Barley breakfast foods and snacks are increasingly available where driven by recent research findings, which show that barley fiber contains beta-glucans and tocotrinols, chemical agents known to lower serum cholesterol levels (Anderson *et al.*, 1990).

In Ethiopia, barley is the third most important cereal crop next to teff and maize. Ethiopia has different type of barley varieties, which highly resist virus diseases (powdery mildew) and also they are rich in protein content. It is the staple food grain for Ethiopian highlanders' those who manage crop with indigenous technologies and utilize different parts of the plant for different purposes. The yield of barley is considered as total biological yield (grain+straw) since in the most dry land areas, barley crop is used for grazing by sheep in the field or harvested for animal feed and roof thatching. Efforts to improve barley have demonstrated a preference for a limited number of modern, genetically uniform cultivars, those suited for high input, to neglect various farmers' varieties (landraces) on which a large sector of the human population has subsisted for food. Barley has been produced in Ethiopia, since ancient times. It has great importance in social and food habit of the people. Both food and malt barley are produced in the country. Despite barley's long history of cultivation, diverse farmers' varieties, traditional practices and its valuable uses, the improvements made to boost the productivity of the crop have been low (Lakew, 2003).

Increasing water limitation is one of the most serious constraints on grain yield in many cereal growing seasons and resulting in the fluctuations of world food and feed supply (Morgan, 1983). Therefore, many attempts have been made by agronomist, plant breeders and physiologists to improve growth productivity and the stability of production by improving agronomic character of the variety. Today, all over the world consumption and production of barley is increased year to year due to its health and nutritional value in human diets (Anderson *et al.*, 1990).

Although, Ethiopia is a center of diversity for barley, most of the country's farmers still obtain very low yields due to a combination of genetic, environmental and socio-economic constraints. Barley is one of the most edible foods in Ethiopia, special at low rain fall area, even if barley is a source of food at low rain fall area its yield production is too low. This is due to reson that farmer cultivate local variety which is less resistance to water stress and low yield and also hybrid lines which released from different research center hadn't been evaluated along wider environment, special at low rain fall area in Ethiopia (Abdi, 2011). Testing of different varieties of barley at different agro-ecology can increases the yielding capacity of barley by selecting high stress resistance variety. Therefore, this study is proposed with the following objectives:

- To select barley varieties for yield potential at low rain fall area
- To increase yield potential of barley by selecting stress resistance varieties

MATERIALS AND METHODS

Experimental materials: Ten barley varieties Diribe (V1), Biftu (V2), Local (V3), Dinsho (V4), Etayesh (V5), Sabine (V6), HB1533 (V7), Bent (V8), MUFBIxp10 (V9) and MUFBIxp125 (V10) were arranged in RCBD in four replications. Each replication contains ten treatments. Seven treatments were collected from Holetta Agricultural Research center, two from Mekelle University and one from Adigidad (farmer variety).

Experimental procedures: The experiment was laid out in Randomized Complete Block Design (RCBD) consisting of four blocks in which 10 varieties were planted, at the seed rate of 100 kg ha^{-1} on the experimental unit with a plot size of 3 m×3 m (9 m^2), 0.5 m between plots and 1 m between replications. The varieties were sowed on 27 June 2011 with diammonium phosphate (DAP) at the rate of 100 kg ha^{-1} (complete application at sowing) and UREA at the rate of 80 kg ha^{-1} (half during sowing and half at vegetative). First, weeds were removed 14 days after sowing and the second weeding were 30 days after first weeding and the last weeding were carried out on 29 August 2011.

Data collection: Based on the IPGRI descriptor list (IPGRI, 1994), all agronomic characters (plant height, number of tillering, day to maturity, disease resistivity, spike length, seed per spike, biological yield, grain yield and harvest index) which determines the biological yield were recorded and analyzed.

Statistical analysis: Analysis of variance (ANOVA) for selection of good performance varieties of barley subjected to low rain fall area were analyzed by using SAS and JMP5. Means were compared by DMRT (Duncan's Multiple Range Test) at a probability level of 5%.

RESULT AND DISCUSSION

Grain yield: Analysis of variances indicated significant difference ($p<0.05$) among genotypes, for all agronomic characters (Table 1). Among varieties, Biftu produced the tallest plant height (103.25 cm), large spike length (9.00 cm), high seed per spike (40), high grain yield (19.44 q ha^{-1}) and greater harvest index (35.250%), while local variety produced high number of tillering per plant (8) with low gain yield (11.11 q ha^{-1}) (Fig. 1). The ranking of genotypes based on their grain yield indicates that Biftu (19.445 q ha^{-1}) ranked first (both in quality and quantity seed) followed by Etayesh (16.668 q ha^{-1}), Diribe (16.665 q ha^{-1}), HB1533 (16.665 q ha^{-1}), Dinsho (15.973 q ha^{-1}) and Sabine (15.278 q ha^{-1}), on other side local (11.110 q ha^{-1}) genotype produced the lowest grain yield followed by MUFBIx10 (12.500 q ha^{-1}) and MUFBIxp125 (13.195 q ha^{-1}) (Fig. 2).

Crop yield is a complex character depending upon a large number of environmental, morphological and physiological characters. This data indicates that yield and yield components were significantly affected by different agronomic characters. Plant height is an important

Table 1: Analysis of variance for agronomic characters

Genotypes	Plant height (cm)	No. of tiller plant^{-1}	Spike length (cm)	Seed spike^{-1}	Biological yield (kg ha^{-1})	Grain yield (q ha^{-1})	Harvest index (HI %)	Straw (kg ha^{-1})
Diribe (V1)	86.00^{c}	5.00^{b}	6.50^{bc}	30.00^{bc}	3333.3^{b}	16.665^{ba}	52.750^{a}	1694.4^{b}
Biftu (V2)	103.25^{a}	7.00^{ba}	9.00^{a}	40.00^{a}	5069.4^{ba}	19.445^{a}	35.250^{b}	3452.8^{ba}
Local (V3)	88.75^{cb}	8.00^{a}	4.50^{dc}	23.00^{dc}	3819.4^{ba}	11.110^{b}	31.500^{b}	2430.6^{ba}
Dinsho (V4)	95.50^{b}	7.00^{ba}	4.00^{dc}	29.00^{dc}	4305.6^{ba}	15.278^{ba}	36.000^{b}	2777.8^{ba}
Etayesh (V5)	93.00^{cb}	5.00^{b}	6.25^{bc}	37.00^{ba}	5416.7^{a}	16.668^{ba}	31.500^{b}	3750.0^{a}
Sabine (V6)	91.00^{cb}	7.00^{ba}	4.00^{dc}	23.00^{dc}	4236.1^{ba}	13.890^{ba}	34.750^{b}	2916.7^{ba}
HB1533 (V7)	92.25^{cb}	7.00^{ba}	4.00^{dc}	23.00^{dc}	5000.0^{ba}	16.665^{ba}	35.000^{b}	2777.8^{ba}
Bentu (V8)	86.00^{c}	7.00^{ba}	5.00^{bc}	39.00^{a}	5347.2^{a}	15.975^{ba}	30.000^{b}	3750.0^{a}
MUFBIxp10 (V9)	86.00^{c}	7.00^{ba}	6.00^{bc}	37.00^{ba}	3750.0^{ba}	12.500^{b}	35.000^{b}	2500.0^{ba}
MUFBIxp125 (V10)	94.00^{cb}	7.00^{ba}	4.00^{dc}	23.00^{dc}	5138.9^{ba}	13.195^{b}	26.500^{b}	3819.4^{a}

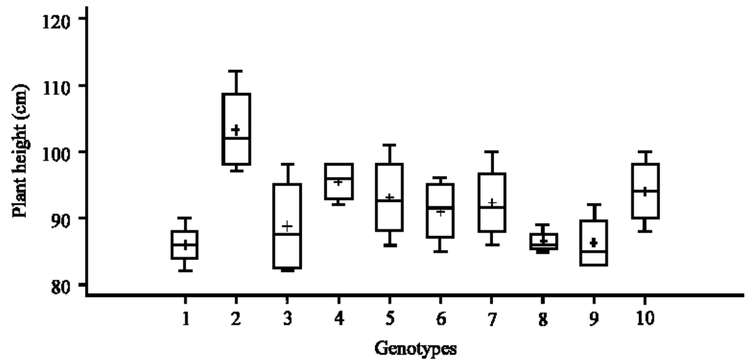

Fig. 1: Plant height of ten barley varieties. 1: Diribe, 2: Biftu, 3: Local, 4: Dinsho, 5: Etayesh, 6: Sabine, 7: HB1533, 8: Bentu, 9: MUFBIxp10 and 10: MUFBIxp125

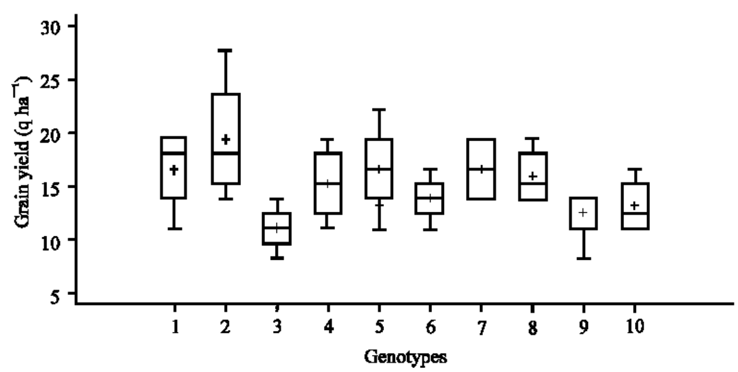

Fig. 2: Grain yields of ten barley varieties. 1: Diribe, 2: Biftu, 3: Local, 4: Dinsho, 5: Etayesh, 6: Sabine, 7: HB1533, 8: Bentu, 9: MUFBIxp10 and 10: MUFBIxp125

morphological character directly linked with the productive potential of plant in terms of grain yield. In stress environment, plant height is directly linked to the productive potential of plant in terms of grain yield and substantial decline in plant height when irrigation was withheld at the booting stage; however, tolerant genotypes attained more plant height (Gupta *et al.*, 2001; Saleem, 2003).

Developmentally, potential stem storage as a sink is determined by stem length and stem weight density. Plant height (stem and spike length), as affected by the height genes, significantly affects stem reserve storage. The dwarfing genes of wheat reduced the reserve storage by 35-39% because of a 21% reduction in stem length (Borrell *et al.*, 1993). Stem size appears to play an important role in plant storage and the capacity of the grain to mobilize storage. Varieties V2 and V4 showed the highest while, varieties V10, V5, V7, V6 and V3 showed medium plant height and varieties V8, V9 and V1 were showed lower plant height (Table 1). In this investigation, analyzed data indicates that increased plant height, increase grain yield. Similarly, Kozlowska-Ptaszynska (1993) was reported that, significant reduction of plant height due to delay in sowing, significantly reduces grain yield in barley.

Those treatments were produced the tallest plant height and produced a greater grain yield (Fig. 1). In field crop production, increase in plant height can expose to wind and reduce crop yield and quality. But increase in plant height to the optimum produce a greater yield.

Number of grain per spike: Statistical analysis for number of seed per spike showed significantly greater for six rows among the genotypes studied, even if two row varieties were produced quality seed (Table 1). Ranking of genotypes for their number of grain seed per spike showed that genotype V2 (40 seeds) was ranked first followed by genotype V8 (39 seeds) (Fig. 3). Water stress at various stages, especially before anthesis, can reduce the number of ear heads and number of grain per spike (Dencic *et al.*, 2000; Guttieri *et al.*, 2001). Both were in well watered and under stress conditions, while water stress imposed during the later stages could additionally induce a reduction in number of grains per spikes and grain weight. The degree of sensitivity to water deficit exists at all stages of plant development, although in barley, there appear to be several critical stages of sensitivity. The first stage appears at the germination, the second one coincides with the floral initiation which reduces both primordia number per surface unit and tillers number and the third level is seen at the anthesis (reduction of grain number per spike, due to pressure on reproduction efficiency). The fourth critical stage is located at the beginning of the milky stage of the grain and reduces grain weight.

According to Ceccarelli (1987), water deficit during the early stage of plant development induces a reduction in spikelets primordia, while water deficit late in the plant development increases death of the flower and the entire spikelet. The number of grains per spike (fertility) depends on the water availability during the early vegetative phase and during the shooting stage. If water deficit occurs after the flowering stage, it induces a decrease of grain weight and thus its yield.

Days to heading and maturity date: This experiment showed that, there is no variation among varieties for their days to heading and days to maturity except variety V6, which is heading after 53 days and matured after 84 days starting from sowing and other all varieties headed after 60 days and matured after 91 days staring from sowing (Table 2). Even, if almost all varieties have non-significant difference for their day to heading and maturity date, their yield performance was significantly difference. Several results obtained by different authors show that number of days to heading and yield were negatively correlated under stress conditions (Acevedo *et al.*, 1991; Mitchell *et al.*, 1996). Positive and significant correlation between days to maturity with days to flowering (r = 0.81) and thousand seed weight with productive tiller per plant (r = 0.64) were reported by Abera (2009). Kebebew *et al.* (2001) reported positive and significant correlation between days to maturity with days to flowering (r = 0.70). According to Mitchell *et al.* (1996), variation in the number of days required to reach anthesis explains 48-72% of the difference in

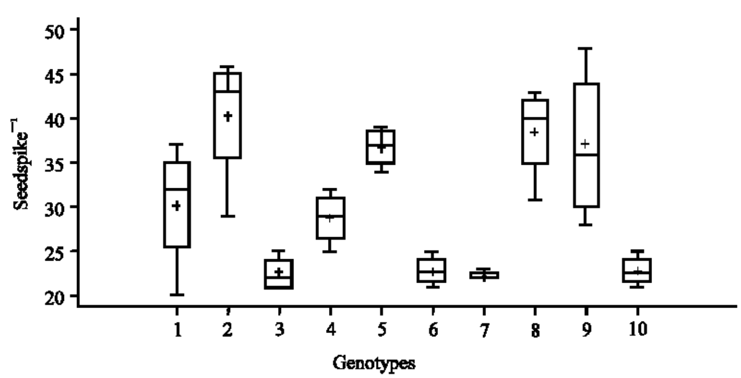

Fig. 3: Number of seeds per spike of ten barley varieties. 1: Diribe, 2: Biftu, 3: Local, 4: Dinsho, 5: Etayesh, 6: Sabine, 7: HB1533, 8: Bentu, 9: MUFBIxp10 and 10: MUFBIxp125

Table 2: Field data record on day to heading, day to maturity, diseases performance and seed purity

Genotypes	No. of rows	Days to heading	Days to maturity	Diseases performance	Seed purity
Diribe (V1)	6	60	91	9	3
Biftu (V2)	6	60	91	9	3
Local (V3)	2	60	91	9	8***
Dinsho (V4)	6	60	91	9	3
Etayesh (V5)	2	60	91	4**	3
Sabine (V6)	2	53	84	9	8
HB1533 (V7)	2	60	91	9	3
Bentu (V8)	6	60	91	4**	3
MUFBIxp10 (V9)	6	60	91	9	3
MUFBIxp125 (V10)	6	60	91	9	3

Source: Field data record, 9: Good diseases performance, 4**: Poor in diseases performance and water susceptible, 3: Good seed purity, 8: Poor seed purity, 8***: Very poor seed purity

Table 3: Correlation coefficients between grain yield and some agronomic traits in ten barley varieties

Correlated traits	r
Plant height (cm)	+0.57*
No. of tillering plant^{-1}	-0.09*
Maturity date	+0.07*'
Spike length (cm)	-0.47*
Seed spike^{-1}	+0.65*
Biological yield (kg ha^{-1})	+0.03*
Harvest index	+0.63*
Straw (kg ha^{-1})	-0.37*
Day to heading	+0.02*

*Significant at 5%

grain yield between barley genotypes. Sensitive genotypes responded with earlier heading and therefore a shortened lifecycle to stress. This condition differs for different genotypes and the rain fall distribution.

Relationship between grain yield and other traits: A correlation was estimated between yield and other agronomic traits evaluated (Table 3). As only a few genotypes were used in the trials and because of the limited degree of freedom, some correlation coefficients were small but significant. Considering all the varieties, at low rain fall area, the correlation between seed per spike and yield under stress conditions was strong (r = +0.63) (Fig. 4). This correlation is more strong correlation for those varieties which possess six row spike type. From this experiment, some variety with six row spike type were reduced spike length and high seed per spike to the top of their spike but other six row spike type were produced high spike length but they were produced low number of seed per spike even if they are six row spike type and also the correlation between day to heading and grain yield was significant at low rain fall area. This confirms the findings in barley by Gonzalez *et al.* (2007) and in other crops by Lopez-Castaneda and Richards (1994), varieties with the earliest ear emergence, provide the highest yields when there is low rain fall at the end of the growth cycle. Mekonnon *et al.* (2014) reported that at higher altitude, there is high rainfall and low temperature which allow longer growing season, longer plant height, high number of seeds per spike but short peduncle extrusion due to high growth of flag leaf and also negative and significant correlation between number of fertile tillers per plant and number of seeds per spike is because plants compete

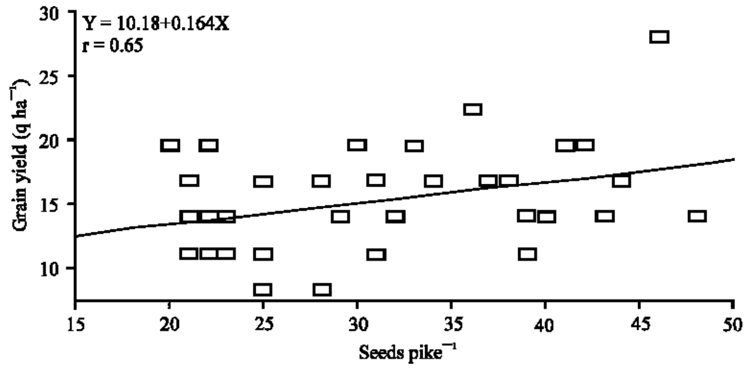

Fig. 4: Correlation between grain yield and seed per spike of ten barley varieties

for food assimilation during growth and development period, in which, it decrease the number of productive tillering per plant.

Correlation between grain yield and agronomic trait indicates that, number of tiller per plant, spike length and straw per hectare were negatively correlated with grain yield (Table 3). This data show that the negative correlation which was produced low yield is mainly due to genotypic character of variety and ways of data collection in barley for number of tillering per plant in barley data collection for number of tillering per plant is recoding of both productive and non-productive tiller per plant, this is due to, non-productive tillering of barley are used as especial biological product). Frank *et al.* (1992) reported that fertile spikelet number decreased significantly in barley as temperature increased from 16-18°C. High temperature also hastened phenological development (Boonchoo *et al.*, 1998).

The effect between grain yield and yield components are, therefore, necessary to increases the yield and yield stability (Garcia del Moral *et al.*, 1991). Considering the correlation found between grain yields and other agronomic traits, it is observed that number of seeds per spike and harvest index were the most significant traits in the selection of barley to improve the yield performance under low rain fall area, in addition to diseases performance.

Harvest index is the proportion of commercial yield to biological yield. Increase in Harvest Index (HI) has been one of the principal factors contributing to genetic yield improvements in spring barley. In plant physiology, increasing photosynthesis can increase crop yield and biological yield but in concept of modern physiology, increasing harvest index can increase crop grain by increasing assimilation of nutrient to grain which is reduce straw. In this investigation, those varieties produced high grain yield were produce high harvest index, this is due to the gene of genotypes which induce grain yield and biological yield. Peltonen-Sainio *et al.* (2008) reported that although high HI demonstrates high-yielding ability when cultivars are compared, it can also indicate challenges to yield formation when comparisons are made across differing growing conditions and also the HI was highest in six-row barley.

CONCLUSION

It can be seen that differences do exist among barley varieties which were studied for their yield performance at low rain fall area based on both quantitative and qualitative characters, Shire, Tigray, Ethiopia since 2011. At low rain area, yield parameters are the most important agronomic traits for selection of varieties. During selection of varieties, across the environment, the gene-environment interaction is the main factors which determine the yield performance of any crops. From this experiment, variety Biftu (V2) was performed well at low rain fall condition as it attained a reasonable both, qualitative (diseases resistance and seed purity) and quantitative (plant height, number of tillering per plant, number of seed per spike, harvest index, biological yield and grain yield) data as compared with other varieties. Developmentally, potential stem storage as a sink is determined by stem length and stem weight density. Plant height (stem and spike length), as affected by the highest genes, significantly affects stem reserve storage which directly affect grain yield. It can be concluded that genotypes with reasonable plant height, good diseases performance and high grain yield are better adapted to low rain fall areas. However, more research is needed on theses genotypes to investigate their potential as parental material for further crosses.

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