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Farmer Participatory Evaluation of Agronomic performance of Malt Barley (*Hordeum vulgare L*) in the high land of Wollo, North eastern Ethiopia

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Abstract

Malt barley (*Hordeum vulgare L.*) is one of the most important industrial crop and highly demanded due to the expansion of brewery factories in the country and the unique nature of the grain for malt. However, its production and productivity is very low compared to other countries due to limited numbers of high yielding malt barley varieties, partial use of agronomic and production and low genetic base due to these farmers were highly resistance to produce malt barley in north eastern Ethiopia. The objectives of this study were to identify malt barley varieties preferred by farmers. Seventeen varieties were evaluated in participatory variety selection (PVS) using RCB design, in Eastern Amhara. The varieties differed significantly for most of the characters and had wide range of mean values, which indicated the existence of variations among the tested varieties. Participatory variety selection was done using pair wise ranking and direct matrix ranking methods. It provides an opportunity to the farmers for variety selection and creates a chance to adopt the new selected varieties easily. Variety HB-1533, IBON174/03, EH-1847 and Friegbs scores the highest yield and highly preferred by farmers which perk up by the community. The above varieties were selected for further multiplication, seed dissemination.

Keywords: Direct matrix ranking • Genetics advance: Heritability • Pair wise rankig methods

Introduction

Barley (*Hordeum vulgare L.*) is an ancient domesticated crop belongs to the family Poaceae, it consists of 32 species with the diploid (2n=2x=14), tetraploid (2n=4x=28) and hexaploid (2n=6x=42) cytotypes in a basic chromosome number x=7, and self-fertility, large chromosome (6-8 µm) high degree of natural and easily inducible variation, ease of hybridization, ease for doubled haploid production and wide adaptation. Globally, barley ranks fourth among the cereal crops after wheat, maize and rice. It has superior nutritional quality due to the presence of beta-glucan (anti-cholestrole substance) and easily digestible due to low gluten content with high vitamin B group. Barley is a cool-season crop that adapted to high altitudes and grows in a wide range of agro climatic regions under several production systems.

Malt barley more preferred to food barley for especially in industrial purpose owing to its unique characters, relatively higher economic return to the farmer and good brewery products other than food crops. However, the big problem that faced barley production in the country was low production per unit area of land. The national average yield of malt barley production estimated at 1.5 ton/ha [1]. Which is very low compare to world average yield 2.9 ton/ha. Low productivity is attributed to the use of old and obsolete variety, low soil fertility, poor weed management, unappropriate fertilizer application. Moreover, in the country conventional research farmer don't involve both in problem identification and evaluation of research result. Consequently, most improved technology had suffered to low rate of adoption [2].

Participatory research increases the job efficiency of the scientists and research costs can be reduced and adoption rates increased if farmers are allowed to participate in variety testing and selection. In addition, production increases when farmers adopt new varieties identified in participatory research [3,4]. Participatory variety selection (PVS) is an approach to provide a great chance to the farmer choice of variety for increasing production in their diversity, socio economical and agro ecological condition. Participatory variety selection approach has provided information to feed back in to the varietal development program and provide direct information technology transfer process by highlighting promising variety and adoption of new variety that address the needs of the farmers and more helps to faster introduction of the new variety to the community. PVS helps to identified preferred cultivars that consist of farmer needs which contain suitable materials to the farmers and fits to the farmers' field. Moreover, once identified variety there were great chance to adapt to climate change, and easily acceptable thereby overcome the constraints that cause farmers to grow old or obsolete varieties [5]. In farmer preferences, farmer gave an important attention to characters other than yield, and that were typically importance to small-scale farmers, such as seed color, spike length, plant height, tiller, seed size, seed per spike, frost resistance, drought resistance, color, overall performances, have been crucial for the increase adoption or rejection of new crop varieties. A farmer can weigh the various characters at least as good as the breeder, since she/he knows the best importance of each of the characters in relation to his or her farming system. Therefore, the main objective of these of experiment is identified preferred malt barley variety by farmer [6,7].

Methods

Description of the study area

The experiment was conducted in Amhara region, Geregra (north

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Wollo), in 2016 main growing season. Geregra is located 665 km North of Addis Ababa at an altitude of 2700 masl. It is located at 110 34' N longitudes, 38° 45' E, latitudes and receiving average annual rainfall of 1147 mm. The soil types are litosols (Tables 1 and 2).

Table 1. List of experimental materials

Variety Name	Releasing Institute/ Center	Year of release	Altitude (masl.)	Rainfall (mm/yr)	Production system
Fanaka	HARC/Meta	2015	2000-2800	700-1000	Late highland potential
Grace	HARC/Heinken	2013	2000-2800	>500	Mid highlands
Traveller	EIAR/Heinken	2013	2000-2800	>500	Mid highlands
Beka	EIAR/HARC	1973	2300-3000	500-800	Highland potential
Sabini	EIAR/KARC/HARC	2011	2300-2800	500-800	Mid highlands
Bahati	EIAR/KARC/HARC	2011	2300-2800	500-800	Late highlands
EH1847	EIAR/HARC	2011	2300-2800	500-800	Late mid highland
Frigebs	ARARI/AARC	2010	2300-3000	500-800	Mid highland
Bekoji- 1	EIAR/KARC	2010	2300-2800	500-800	Late highland
Misccal-21	EIAR/HARC	2006	1550-2850	500-800	Medium to high
HB 1963	HARC	2016	>2300	700-1000	Late highlands
HB 1964	HARC	2016		700-1000	Late highlands
HB 1533	EIAR/HARC	2003	2300-2800	500-800	Highland potentials
HB-52	EIAR/HARC	2001	2300-2800	500-800	High to medium
HB-120	EIAR/HARC	1994	2300-2800	500-800	High to medium
IBON 174/03	EIAR/HARC	2012	2300-2801	500-800	Mid Highlands
Holker	EIAR/HARC	1979	2500-3000	500-800	High potentials

*HARC=Holetta agricultural research center, EIAR=Ethiopian Institutes of Agricultural research, KARC=Kulumsa Agricultural Research center, Adet agricultural research center, LM=low, medium and HP= High, Potential

Table 2. Estimation of agronomic mean value conducted at Geregra 2016

Variety	DH(days)	DM(days)	GF(days)	GY(kg/ha)	BM(kg/ha)	HI	PH(cm)
Fanaka	86d	130bcdefg	44ab	840a	2333abc	0.359ab	51.33ab
Grace	91e	133.7defg	42.67ab	806a	2417abc	0.3362a	49a
Traveler	91e	135.3eg	44.33ab	969ab	2317abc	0.4165abcde	48.67a
Beka	86d	133.3cdefg	47.33b	1164cd	2500abc	0.4691defg	72.33ef
Sabini	80.67bc	124.3ab	43.67ab	855a	2042a	0.4247bcdef	56.67abc
Bahati	86d	129bcdefg	43ab	837a	2233abc	0.3797abc	57.33abc
EH1847	81bc	124ab	43ab	1056bc	2333abc	0.4525cdefg	64.67cde
Frigebs	80bc	124ab	44ab	1251de	2833bc	0.446cdef	73.17ef
Bekoji1	86.67d	125.7b	39a	996abc	2667abc	0.3852abcd	70def
Miscal	81bc	126.7bc	45.67ab	1289de	2708abc	0.4749efg	66cdef
HB1963	87.67d	128.7bcdef	41ab	858ab	2083a	0.4281bcdef	62.67bcde
HB1964	81.33bc	125.3b	44ab	1067bc	2500abc	0.4269bcdef	59abcd
HB1533	79.67b	124ab	44.33ab	1489f	2917c	0.5316g	77.67f
HB- 52	91.33e	135.3efg	44ab	857a	2175ab	0.3977abcde	64.33cde
HB-120	82c	127bcd	45ab	935ab	2625abc	0.3549ab	67.33cdef
IBON	73.67a	118.7a	45ab	1432ef	2833bc	0.5053fg	63.33bcde
Holker	85.67d	128.7bcdef	43ab	926ab	2567abc	0.361ab	55abc
Mean	84.16	127.86	43.71	1038	2475	0.42	62.26
CV	4.3	3.8	7.8	10.1	14.3	10.4	10.2

*DH=days to heading, DM=days to maturity, Gf=grain filling, Gy=Grain yield, BM=biomass, HI=Harvest indix and PH=plant height

Experimental design and field lay out

The trial was laid out in Randomized Complete Block Design (RCBD) with three replications. The plot size was 1.60 m wide and 2.5 m long with a total area of 4 m2 consisting of 8 rows. The spacing between rows, plot and replication was 20 cm, 0.5 m and 1 m, respectively. The experiment was planted following the farmer trends. The seed rate was 100 kg/ha, and seeds were drilled in each row. Fertilizer was applied 41/46 of (N/P2O5) per hectare.

Farmers' preference evaluation

Twenty three representative and model farmers were participated in the malt barley variety selection. Participant farmers were selected based on their indigenous knowledge on barley production. Selected farmer makes focus group to assess all farmers view and perception on each variety which helps the farmers involving in planning, excursion, monitoring and promotion of new variety and targeted to enhance on farm varietal diversity. Varieties selections were conducted using focus group discussion (FGDs) using participatory tools such as Pair wise ranking and Direct Matrix ranking methods. The criteria included agronomic characters such as frost resistance, drought resistance, earliness (dates of heading, dates of maturity) spike length, seeds per spike, yield performance, and color. A few farmers had the chance to evaluate the varieties starting from emergency to maturity and some farmer visited the trials at the heading stages but the overall performances of the variety were evaluated and make selection at maturity stage.

The ranking procedures were explained to the farmers and they ranked each variety by observing the whole experimental units. Scores were given to each variety based on the selection criteria (1=very good, 2=good, 3=average, 4=poor and 5=very poor). Each farmer had a right to select from one to five to score and multiplied by the number of farmer to set cumulative rank and the cumulative rank also multiplied by the weight of the characters to standardized the rank of the final result selected variety the total scores a given variety. According to Boef and Thijssen (2006) scoring and ranking were done on consensus of participating farmers, where difference were solved by discussion in pair wise ranking but in direct matrix ranking each had a right to score 1-5. Both men and women were equally involved in the variety selection process. The degree of correlation coefficient in farmer preference and actual grain yield (After measuring actual yield) by using spearman correlation coefficient by using the following formula.

$rs=1-(6\sum d^2)/(n(n^2-1))$

Where, rs=correlation coefficient

d=difference in the ranks assigned to the same individual or phenomenon and

n=number of individuals or phenomena ranked

Results

Five malt barley varieties were selected as the best varieties for malt barley production which were HB-1533 and IBON 174/03 ranked first and second followed by Beka, miscal-21 and EH-1847. In other hand Varieties HB-120, HB-52, Holker, HB-1963 and Grace scored lowest rank. Farmer preference indicated that variety EH 1847, Frigebs and HB-1533, and IBON, 174/03 relatively short days to head and mature with good yields which have the capacity to give good yield (Table 3).

Table 3. Spearman rank correlation coefficients= 69% Pair wise ranking methods of seventeen malt barley varieties studied in 2016 at Geregra.

Variety	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total	AY.R	Rank
Fanaka		1	1	4	1	1	1	1	1	1	1	1	13	1	1	16	1	13	15	4
Grace			3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	0	17	17
Traveller				4	5	6	7	8	9	10	11	12	13	14	15	16	17	1	9	16
Beka					4	4	4	4	4	4	4	4	13	4	4	16	4	14	5	3
Sabini						5	7	8	5	10	5	12	13	5	5	16	2	8	14	9
Bahati							7	8	9	10	11	12	13	14	15	16	17	2	16	14
EH1847								7	7	7	7	12	13	7	7	16	7	12	7	5
Friegebs									8	10	8	8	13	8	8	16	8	10	4	7
Bekoji-1										10	9	12	13	9	9	16	9	7	8	10
Miscal21											10	10	13	10	10	16	10	11	3	6
HB 1963												12	13	14	11	16	17	4	12	13
HB 1964													13	12	15	16	12	9	6	8
HB1533														13	13	13	13	16	1	1
HB-52															15	16	14	5	13	12
HB-120																16	15	6	10	11
IBON																	16	16	2	1
Holker																		2	11	14

A.Y.R=average yield rank (after measuring actual yields).

Frost resistance, drought resistance, earliness, yield performance, spike length, seed per spike and biomass were an important selection criterion for farmer relation to escape the frost and moisture stress in the study area and provide food security in the highland of the country and import substitution of malt barley in the country. Variety IBON 74/03 and HB 1533 scored short days to head and mature due to this more preferred variety for production. Farmer point out which is frost and moisture deficit was the major barley production problem. Due to these farmers select the above variety for production. Almost all tested variety had similar grain filling period. The overall correlation coefficients in pair wise ranking methods with actual grain yields in farmer preferences acceptability ranks score 69%. Moreover, HB1533, and variety IBON 174/03 showed goods coincidence in

Table 4. Spearman rank correlation coefficients =65%. Selection of malt barley variety using different characters in direct matrix ranking method at Geregra 2016

Variety	SL(9)	SS(5)	Ph(10)	Tl(6)	Ea(2)	Fr(2)	Dr(1)	SPS(7)	Y(2)	C(8)	Total	Rank	AY.R
Fanaka	36	70	40	24	8	8	4	28	8	32	258	5	15
Grace	126	75	140	84	28	28	14	98	28	112	733	16	17
Traveller	135	35	150	90	30	30	15	105	30	120	740	17	9
Beka	63	55	70	42	14	14	7	49	14	56	384	8	5
Sabini	99	65	110	66	22	22	11	77	22	88	582	14	14
Bahati	117	10	130	78	26	26	13	91	26	104	621	15	16
EH1847	18	40	20	12	4	4	2	14	4	16	134	2	7
Friegebs	72	30	80	48	16	16	8	56	16	64	406	10	4
Bekoji- 1	54	25	60	36	12	12	6	42	12	48	307	7	8
Misccal21	45	40	50	30	10	10	5	35	10	40	275	6	3
HB 1963	72	15	80	48	16	16	8	56	16	64	391	9	12
HB 1964	27	5	30	18	6	6	3	21	6	24	146	3	6
HB 1533	9	45	10	6	2	2	1	7	2	8	92	1	1
HB-52	81	50	90	54	18	18	9	63	18	72	473	11	13
HB-120	90	20	100	60	20	20	10	70	20	80	490	12	10
IBON 174/03	36	60	40	24	8	8	4	28	8	32	248	4	2
Holker	108	0	120	72	24	24	12	84	24	96	564	13	11
A.Y.R= average yield rank (after measuring actual yields).													

ranks of the yield and farmer preference (Table 4).

Discussion

According to analysis of variance and farmer evaluation five malt barley varieties were selected as the best varieties which were HB-1533 and IBON-174/03 ranked first and second followed by Beka, fanaka, miscal-21 and EH-1847. Whereas, Varieties HB 120, HB 52, Holker, HB 1963 and grace scored lowest rank at the lowest. Farmer preference indicated that variety EH-1847, Frigebs and HB-1533, and IBON, 174/03 relatively short days to head and mature with good yields which have the capacity to give goods yield for home consumption. Farmers were more impressive especially on Variety IBON 174/03 in early heading and mature with average yield performance.

Most farmers revealed that the reasons for the preference of a variety were related to many characters which help to solve the problem that hinder their maximum production. Frost resistance, drought resistance and earliness remains as an important selection criterion for farmers related to escape the frost and moisture stress in the study area and provide foods in the highland of the country. Developing variety which is frost and drought resistance is the priority agenda for farmers in their selection criteria. So far the areas were highly affected by frost and terminal moisture stress. Farmers strongly focused on yield performance in related to tiller and earliness to escape the above production problem and to get reasonable yield. When a variety is resistant to frost or early maturity before frost and drought appear, is the ultimate goal of the farmer. Large seeds size were more attractive and produce large grain with more powders thereby increase yield. The next important character was seeds per spike, when the numbers of seed per spike high grain yield per plot. Plant height was not that much important for selections criteria followed by color. But if the above criterion fulfills long plant height, long spike length along many seeds per spike with white color preferred by the farmers.

Participatory variety selection is a more rapid and cost effective way of identifying variety to produce farmer acceptable variety, particularly the areas with terminal moisture stress. The selected varieties were suggested for these niches after validation of results through farmer preference and analysis of variance to confirm the real performance which helps is used for up scaling. Identified variety for predication potential need to be popularized through in the highlands area of wollo and surrounding barley production belt area to cover large potential area for supplying malt barley grain for malt factory.

Conclusion

Spearman rank correlation is non-parametric test that is used to measure the degree of association between two variables and see the degree of coincidence between farmers' acceptability rank and actual yield rank, (Grain Yield after measuring actual yield). Varieties HB1533, and IBON 174/03 had showed that 100% coincidence the actual yield and in the field condition in farmer preference. However, the overall correlation coefficients in pair wise ranking and direct matrix ranking methods with actual grain yields in farmer preferences acceptability ranks score 69% and 65% respectively.

Conflict of Interest

We have no conflict of interests to disclose and the manuscript has been read and approved by all named authors.

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