ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Journal of Agronomy, 4 (4): 333-339, 2005
ISSN 1812-5379

Agronomic Factors on Selected Hulless Barley Genotypes

Hamid Reza Balouchi, Zeinalabedin Tahmasbi Sarvestani and Seyed Ali Mohammad Modarres Sanavy
Department of Agronomy, Faculty of Agriculture, Tarbiat Modarres University,
Tehran, P.O. Box 14115-336, Iran

Abstract: Yield and yield components evaluation of different hulless barley (*Hordeum vulgare* L.) genotypes with objective determination of the best plant density and nitrogen fertilizer rate is necessary for obtaining maximum quality and quantity yield. In the first year, for these propose twenty genotypes were evaluated in aspect of quality and quantity yield. In second experiment, ten best genotypes selected from the first experiment were evaluated for agronomic factors such as plant density and N fertilizer rate application. Both experiments were conducted in Research Farm of Tarbiat Modarres University, College of Agriculture, Tehran, Iran during 2001-2003 growing season. The experimental designs of first and second experiments were Randomized Complete Block and Split-Split-Plot laid out in Randomized Complete Block designs, respectively, with three replications and a total of ten genotypes (as main plot), 2 levels of nitrogen fertilizer (90 and 120 kg nitrogen ha^{-1} as subplot) and 3 plant densities (300, 400 and 500 plants m^{-2} as sub sub-plot). The results showed that a significant difference between genotypes and plant density interaction in grain yield and harvest index. The highest grain yield, spike number m^{-2} and grain number spike^{-1} were produced by ALLSO'S'/C103902-2 genotype under 500 plant m^{-2}. FICC2595 Genotype showed the highest thousand-kernel weight (46 g) and FICC1570 genotype produced the highest spike number m^{-2} (958 spike m^{-2}). The mean comparison of protein yield in different plant density m^{-2} showed that 500 plants m^{-2} treatment produced the highest protein yield (58.48 g m^{-2}).

Key words: Hulless barley, *Hordeum vulgare* L., plant density, nitrogen fertilizer, yield, yield components

INTRODUCTION

Barley (*Hordeum vulgare* L.) has the widest geographical range of distribution of all cereals. In temperate, humid climate, barley can be sown in an autumn and harvested after about 300 days. It also grows under arid climates. The varieties adapted to the respective conditions are quite different from each other. All of these many types of barley developed characteristic traits, which always refer to the environmental conditions. One character of special interest, which has developed in different areas, is the feature of free threshing grains, i.e., the grains are not covered with the glumes after threshing (hulless barley).

Hulless barley research and development is now receiving more emphasis with potential for feed, food and industrial uses. Variety selection is and will become more important as the various industries demand specific characteristics. Feeding value depends on its protein and energy contents. In agriculture, besides the grain quality, the adaptation of the varieties to the respective site of cultivation is the greatest importance.

Hulless barley is important source of water-soluble plant fiber needed in human diets to lower serum cholesterol. Reported benefits of water-soluble plant fiber from hulless barley[1] in lowering human serum cholesterol have increased the interest in producing hulless barley for human consumption. Thus, production practices such as plant density and N fertilization may be important.

The hull comprises 10-13% of barley dry matter[2], therefore its absence in hulless forms results in the greater content of nutrients, mainly protein and fat. The presence of hull, which is made up of chiefly cellulose and lignin, decreases the digestibility of all nutrients.

Hulless barley is very well suited to Iran region fitting well with the cropping systems and potentially providing grain for the poultry industries in addition to current uses. Hulled barleys have not generally been fed due to the high fiber content and hulless barley has not been utilized due to the low yield varieties for the Iran region.

Hulless barley has the potential to produce yields similar to wheat with a combination of positive nutritional qualities from hulled barley and wheat[3].

Corresponding Author: Syed Ali Mohammed Modavies Sanavy, Department of Agronomy, Faculty of Agriculture, Tarbiat Modares University, Tehran, P.O. Box 14115-336, Iran Tel: (+98) 021 44196991

Compared with hulled barley cultivars, hulless cultivars have reduced fiber content and increased starch content due to the absence of the hull[4]. The crudeprotein of hulless barley typically exceeds that of comparable hulled types and should be 1-2% greater. Hulless barley has a major advantage over conventional barley in transportation, processing and storage. Removing the hull fraction increases the bulk density (weight-per-unit volume) compared to conventional barley by about 25 %.

Grain yield in barley depends mainly on spikes m^{-2} and kernels $spike^{-1}$[5-8]. Yield components are formed during successive stages in the ontogeny of plants and earlier formed components influence those that develop later[5]. Previous studies have shown that yield components such as grain yield; spike number m^{-2}, grain number $spike^{-1}$ and thousand kernel weight interact with yield and thereby in the affect grain yield[5,7,8]. Thus plant population density influence on spikes m^{-2} and thereby in the affect grain yield.

Good understanding from plant nitrogen future is major objective in developing utilization of nitrogen and mineral fertilizer and reducing contamination of subterranean water[9]. Morgan and Smith[10] investigated the effect of 0, 45, 90, 135 and 180 kg ha^{-1} nitrogen rates on spring wheat. They showed that the most grain yield and grain nitrogen rate were obtained from 135 and 180 kg ha^{-1} nitrogen treatments, respectively. Previous studies reported positive effect of optimum nitrogen fertilizer application on grain yield[11-14]. High nitrogen application increased forage protein yield due to more nitrogen absorption and increasing vegetative growth (15).

Numerous studies have been conducted to examine the effect of plant density and N fertilizer on yield of small grains. However, few experiments have examined the influence of agronomic factors in hulless barley. The objective of this study was to rank 20 barley genotypes on the basis of their protein and yield. Then the selected genotypes were evaluated for the best nitrogen fertilizer rates and population densities for acquiring the maximum quality and quantity yield.

MATERIALS AND METHODS

This study included two field experiments planted at the Research Farm of Tarbiat Modarres University, College of Agriculture, (35°43′ N Latitude, 51°8′ E Longitude and 1215 m Altitude), Iran, for two growing seasons in 2001-2002 and 2002-2003. Yearly average rainfall is 247.4 mm and yearly averages of the maximum and minimum temperatures were 37 and 0°C. The soil characters are shown in Table 1. Two experiments were conducted separately due to have different materials and methods.

Experiment 1: The experimental field was planted to wheat in 2000 but was a fallow in 2001. Basal fertilizers were applied to the soil including 60 kg ha^{-1} (P_2O_5) ammonium phosphate and 120 kg ha^{-1} urea. N fertilizer was applied two times (½ basal and ½ at active tillering stage) as top dressing. Standard cultural practices were followed. The experimental design was Randomized Complete Block with three replications. Twenty hulless barley genotypes were used for this study. Each experimental plot consisted of five 1.5 m rows with a row spacing of 20 cm. Plant density was consist of all genotypes and was 350 plants m^{-2}. Two middle rows in each plot were harvested for yield determination. Grain yield, thousand kernel weight and spike number m^{-2}, grain number $spike^{-1}$, harvest index and protein percent were recorded for each plot. Superior genotypes were selected for higher grain and protein yield. Then selected genotypes were used in second experiment.

Experiment 2: The experimental field was planted to wheat in 2001 but was a fallow in 2002. Before preparing field, soil samples were taken from 0-30 cm deep for soil physical and chemical determining. Fertilizer was applied in basis of soil analysis (Table 1). A main fertilizer including 300 kg ha^{-1} ammonium phosphate (46% P_2O_5 and 18% N) was applied to the soil before planting.

A split split-plot was designed with 10 genotypes (Table 2) as main plots, N treatments (90 and 120 N kg ha^{-1}) as sub-plots within the main plots and plant density (300, 400 and 500 plants m^{-2}) as sub sub-plots. There were 3 replications. Each sub sub-plot was made up of four rows of 2 m length. The rows were 20 cm apart. The adjacent sub sub-plots were separated by two blank rows. The distance between main plots was 1.5 m. Urea fertilizer (46%) were applied two times (½ basal at planting date and ½ at active tillering stage) according to N treatments. Genotypes seeds was sown on 15 November 2003. Seeds were surface sterilized with 0.02% (w/v) Mankozeb fungicide (IMP and Exp Corporation). Experimental plots were kept free of weeds and pests. At maturity, two rows of each sub sub-plots were harvested and the following data were recorded: grain yield; spike number m^{-2}, grain number $spike^{-1}$, thousand kernel weight, harvest index, protein percent and yield.

Statistical analysis: Results were statistically analyzed for variance using the SAS system[16]. When analysis of variance showed significant treatment effects, Duncan's multiple range tests was applied to compare the means at $p<0.05$[17].

Table 1: The soil texture analysis information

Deep (cm)	Clay (%)	Sand (%)	Silt (%)	Phosphorus (ppm)	Total nitrogen (%)	pH	Electrical conductivity (μMol $cm^{-2}s^{-1}$)
Experiment 1:							
0-20	13.3	76.9	9.7	6.4	0.10	7.8	1.4
20-40	14.0	77.0	9.0	4.6	0.23	7.5	1.7
Experiment 2:							
0-30	24.4	59.0	16.6	5.0	0.05	7.4	1.03

Table 2: International code and brief sign of 10 genotypes of hulless barley that selected for second experiment

Brief. Sign	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
International code	FICC 1571	FICC 1570	FICC 1329	FICC 1301	FICC 1725	FICC 0963	FICC 2595	FICC 2712	FICC 1461	ALISO "S"/C103909-2

RESULTS AND DISCUSSION

Experiment 1

Grain yield: Present results indicated that genotypes had ($p<0.01$) significant difference for grain yield, thousand kernel weight, spike number m^{-2}, grain number $spike^{-1}$, harvest index and protein percent (Table 3). Mean comparisons showed the maximum grain yield for FICC1571 genotype with 3963 kg ha^{-1} and minimum grain yield for FICC0406 genotype with 1714 kg ha^{-1} (Table 4). It is seems that high yield of FICC1571 genotype is due to its high harvest index and spike number m^{-2} in comparison with other genotypes (Table 4). Low grain yield in FICC0406 genotype was due to low spike number m^{-2} and grain number $spike^{-1}$ in this genotype (Table 4). Many researchers[18-22] also that believe increasing yield are due to enhance spike number m^{-2}.

Thousand kernel weight: FICC2712 and FICC2595 genotypes had more thousand kernel weight (47 and 46 g, respectively) than other genotypes. The lowest thousand kernel weight was obtained from FICC0409 and FICC0598 genotypes (24 g) (Table 4). More thousand kernel weight in FICC2712 and FICC2595 is due to have awn and low grain number in spike in these genotypes than others. Plant current photosynthesis is most important source for grain barley storage in suitable condition. Awn increase plant photosynthesis potential and as a result seed length and width increase and thereby in the end affect thousand kernel weight. Low thousand kernel weight in FICC0409 and FICC0598 genotypes is due to high grain number in spike of these genotypes.

Spike m^{-2}: ALLISSO"S"/C103909-2 genotype had the most spike m^{-2} (389). This trait was the lowest in FICC0406 and FICC1329 (196 and 202, respectively) (Table 4). Higher spike number in ALLISSO"S"/C103909-2 is related to high genetic potential. There is positive correlation between spike number and grain yield. As was shown here the ALLISSO"S"/C103909-2 genotype had high grain yield. Some researchers have reported that spike number m^{-2} have direct effect on grain yield, although high spike m^{-2} cause to decrease grain number $spike^{-1}$[23]. As was shown (Table 4) FICC1329 genotype had the highest and lowest grain number $spike^{-1}$ and spike number m^{-2}, respectively.

Grain number in spike: Analysis of variance on grain number/spike was shown that grain number $spike^{-1}$ had significant difference among hulless barley genotypes (Table 3). Mean comparisons showed that the maximum grain number $spike^{-1}$ was for FICC0963 and FICC1329 (54 grain) and the minimum was observed in FICC2712 and FICC2595 genotypes (21 grain) (Table 4). Higher grain number $spike^{-1}$ in FICC0963 and FICC1329 genotypes in comparison with other genotypes are due to higher genetic potential, lower thousand grain weight and spike number m^{-2} (Table 4).

Lower grain number $spike^{-1}$ in FICC2712 genotype is due to lower spike number m^{-2} and thousand grain weight in comparison with other genotypes. Increasing spike number and plant population enhance competition between plants and as a result decrease grain number and increase thousand grain weight due to compensation effects.

Grain protein percent: FICC1461 and FICC0406 had the most grain protein percent (11.61 and 11.31%, respectively). The lowest grain protein percent was belong to FICC 1570 genotype (Table 4). Protein percent was high in FICC1461 and FICC0406 genotypes due to low grain number $spike^{-1}$ and spike number m^{-2}. There are negative correlation between protein percent with grain yield, harvest index, grain number $spike^{-1}$ and spike number m^{-2}. Thus FICC0406 genotype had the maximum protein percent and minimum grain yield and harvest index.

On the whole, FICC1571, FICC1725, FICC 0409, ALLISSO"S"/C103909-2 and FICC 1301 genotypes produced 3963, 3700, 3650, 3510 and 3408 kg ha^{-1} yield,

Table 3: Variance analysis of measured traits for 20 hulless barley genotypes in first experiment

		Mean square					
S.O.V	DF	Grain yield (kg ha^{-1})	Harvest index	Thousand kernel weight	Grain number Spike^{-1}	Spike number (m^{-2})	Protein
Replication	2	69242.429 ns	0.222*	85.370**	50.429*	3070.317 ns	1.275 ns
Genotype	19	835249.283**	0.324**	116.647**	265.517**	9586.473**	4.127**
Error	38	87281.85	0.057	11.227	10.378	1052.983	0.763
C.V%		9.88	3.78	10.43	7.9	11.54	8.92

*Significant at 5%, **Significant at 1% and ns not significant

Table 4: Mean values (Duncan's Test, $p<0.05$) of measured traits for 20 hulless barley genotypes in first experiment

Genotype	Protein (%)	Harvest index (%)	Grain yield (kg ha^{-1})	Grain number spike^{-1}	Spike number (m^{-2})	Thousand kernel weight (g)
FICC1571	7.31cd	47ab	3963a	40def	357ab	29cdefg
FICC1725	10.40ab	42abcde	3700ab	43cdef	356ab	46ab
FICC0409	9.59abc	39bcdef	3650abc	46abcd	304abcd	24g
ALLISSO"S"/C103909-2	10.14ab	37def	3510abcd	39def	389a	30defg
BF891 M-584	10.31ab	37def	3344abcde	37efg	382ab	32cdefg
FICC1301	9.30abcd	40bcdef	3408abcde	42def	262ede	29defg
FICC0963	9.21abcd	46abc	3083bcdef	54a	232cde	35cde
BF891 M-614	8.80bcd	38bcdef	2930bcdefg	34fg	260cde	34cdef
FICC1570	7.21d	49a	3004bcdefg	51abc	258cde	29defg
FICC1329	10.75ab	39bcdef	3066bcdefg	54a	202e	34cdef
ICNBF 8-654	10.75ab	44abcd	2868cdefg	42def	258cde	38bc
FICC2712	9.30abcd	43abcde	2874cdefg	21h	302bcd	47a
FICC0463	11.10ab	39bcdef	3060cdefg	40def	222de	26fg
BF891 M-609	9.49abcd	39bcdef	2796defg	35efg	316abc	35cde
FICC1235	9.42abcd	38bcdef	2820defg	44bcde	250cde	27efg
FICC2595	9.30abcd	38bcdef	2668efg	21h	310abcd	46ab
FICC1392	10.81ab	41abcde	2705efg	47abcd	243cde	29cdefg
FICC0598	9.70ab	35ef	2360fge	51ab	259ede	24g
FICC1461	11.61a	31f	2278gh	46abcd	266cde	28defg
FICC0406	11.31a	38cdef	1714h	30g	196e	36cd

Mean within columns with different letter are significantly different at 5% for a duncan test

Table 5: Variance analysis of measured traits for 10 hulless barley genotypes under different levels of plant population and nitrogen fertilizer

		Mean square					
S.O.V	DF	Grain yield	Grain number spike^{-1}	Spike number (m^{-2})	Thousand kernel weight	Harvest index	Protein yield (%)
Replication	2	3.24ns	40.87ns	53531.34ns	18.882ns	264.245ns	27.09ns
Genotype	9	5.018ns	3490.09**	112184.63**	980.451**	197.715ns	60.215ns
Main error	18	2.65	71.119	23572.28	34.881	106.877	26.063
Fertilizer	1	0.39ns	113.605*	1626.001ns	0.512ns	3.816ns	12.293ns
Genotype *fertilizer	9	1.939ns	33.53ns	15142.10*	33.706ns	58.490ns	17.828ns
Sub error	20	1.123	16.73	4940.961	17.972	30.289	11.8
Density	2	5.212**	26.73ns	148207.07**	5.093ns	0.007ns	110.37**
Genotype *density	18	2.42**	14.948ns	13532.53ns	16.762ns	59.602**	19.519ns
Fertilizer *density	2	0.896ns	42.27ns	3135.74ns	16.761ns	4.766ns	3.628ns
Genotype *fertilizer* Density	18	0.52ns	18.75ns	6000.36ns	12.429ns	28.713ns	3.548ns
Sub sub error	80	1.049	17.42	8470.172	12.97	25.86	12.463

*Significant at 5%, **Significant at 1% and ns not significant

respectively and these genotypes had more yield than others. FICC 1461 and FICC 0406 had the most protein percent (11.61 and 11.31, respectively). FICC 0963 had the most spike grain number and relatively high protein percent. FICC1570 had the most harvest index. The most thousand kernel weight was belong to FICC2595 and FICC2712. Therefore FICC1725 genotype with 3700 kg ha^{-1} grain yield and 10.40% protein and also ALLISSO"S"/C103909-2 genotype with 3510 kg ha^{-1} grain yield and 10.14% protein were determined as the best genotypes in this environment.

Experiment 2

Grain yield: There was significant interaction ($p<0.01$) between genotypes and plant densities for grain yield (Table 5). ALLISSO"S"/C103909-2 genotype had the most grain yield (5874 kg ha^{-1}) at 500 plant m^{-2} (Table 6). Higher grain yield in ALLISSO"S"/C103909-2 is related to its high spike number m^{-2}, grain number spike^{-1}, thousand grain weight and 6 row-spike in comparison with other genotypes (Table 8). FICC2712 genotype with low grain yield had low spike number m^{-2} and two-row spike. Yield in other genotypes enhance with increasing

Table 6: Mean comparisons among barley genotypes for grain yield in different plant density (p<0.05)

	Plant density (m^2)		
Genotype	300	400	500
FICC1571	3996bcde	4035bcde	3224cdefg
FICC1570	4758ab	3180cdefg	4511bc
FICC1329	2440fg	2813defg	3882bcdefgh
FICC1301	2608efg	3912bcde	3140cdefg
FICC1725	3368bcdefg	3904bcde	3368bcdefg
FICC0963	3970bcde	3610bcdefg	4402bc
FICC2595	3698bcdefg	3560bcdefg	3856bcdef
FICC2712	2325g	3210cdefg	2870defg
FICC1461	2838defg	2682defg	4080bcd
ALISO "S"/CIO3909-2	3586bcdefg	3960bcde	5874a

Mean within columns with different letter are significantly different at 5% for a duncan multiply range test

Table 7: Mean comparisons among barley genotypes for harvest index in different plant density (p<0.05)

	Plant density (m^2)		
Genotype	300	400	500
FICC1571	38.20ab	33.96abcdefg	28.27ghf
FICC1570	39.15a	30.74cdefgh	34.78abcdef
FICC1329	26.72h	27.38gh	31.90bcdefgh
FICC1301	28.62efgh	36.65abcd	30.01defgh
FICC1725	34.06abcdefg	35.50abcd	31.63bcdefgh
FICC0963	34.87abcdef	34.83abcdef	36.78abcd
FICC2595	36.85abcd	37.30abc	37.58abc
FICC2712	26.75h	28.77efgh	26.56h
FICC1461	31.86bcdefg	29.16efgh	33.90abcdefgh
ALISO "S"/CIO3909-2	34.19abcdefg	36.32abcd	40.32a

Mean within columns with different letter are significantly different at 5% for a duncan multiply range test

Table 8: Mean values (Duncan's test, p<0.05) of yield components for 10 hulless barley genotypes in second experiment

Genotype	Grain number $spike^{-1}$	Spike number (m^{-2})	Thousand kernel weight (g)
FICC1571	53b	500b	25de
FICC1570	53b	625a	24de
FICC1329	58ab	342c	23e
FICC1301	53b	418bc	27de
FICC1725	56b	454bc	25de
FICC0963	64a	386bc	28d
FICC2595	23c	443bc	45a
FICC2712	25c	404bc	39b
FICC1461	55b	384bc	24de
ALISO "S"/CIO3909-2	56b	468b	32c

Mean within columns with different letter are significantly different at 5% for a duncan test

Table 9: Mean comparisons among spike number m^{-2} and protein yield of in different hulless barley plant densities in second experiment (p<0.05)

	Plant density (m^2)		
	300	400	500
Spike number m^{-2}	406.33b	421.93b	499.15a
Protein yield (g m^{-2})	47.88b	51.2b	58.48a

Mean within columns with different letter are significantly different at 5% for a duncan multiply range test

Table 10: Mean comparisons among hulless barley grain number $spike^{-1}$ in different N fertilizer rates in second experiment (p<0.05)

	N fertilizer rates (kg ha^{-1})	
	90	120
Grain number $spike^{-1}$	48.73b	50.32a

Mean within columns with different letter are significantly different at 5% for a Duncan Multiply Range Test

population density up to somewhat and then decrease due to sensitiveness of genotypes to high population and inter competition appearance. Mazurek *et al.*[24], Grabinski[20], Anderson[25], Piegh *et al.*[21] and Stankowski[22] which showed spike density enhancement increased grain yield. Yield decrease in high plant population decrease grain yield due to stem lodging. Grain yield had the highest correlation with spike number m^{-2} (r = 0.564) and harvest index (r = 0.743).

Thousand kernel weight: The most thousand kernel weight was observed in FICC2595 (45 g) genotype (Table 8). More thousand kernel weight in FICC2595 genotype is due to its awn, more spike length (data not shown) and low grain number in spike. Plant current photosynthesis is the most important source for seed barley storage in suitable condition. Awn and spike length increase plant photosynthesis potential and as a result seed length and width increase and thereby in the affect thousand kernel weight. There was non significant effect between different plant population, nitrogen fertilizer rates and their interaction effects on thousand grain weight. These results according to Kabirian *et al.*[19] Garcadel *et al.*[7].

Spike number m^{-2}: FICC1570 genotype had the most spike number m^{-2} (625) (Table 8). Higher spike number in FICC1570 genotype is related to high genetic potential. Plant density increased spike number m^{-2}. The most spike number m^{-2} was observed at 500 plant m^{-2} plant density (Table 7). There is positive correlation between spike number and grain yield, Although high spike m^{-2} decreased grain number spike^{-1}[23]. This result is comparable to the previous report of Kabirian *et al.*[19] which showed high plant densities decreased spike number m^{-2} due to competition. Some researchers reported that high plant densities did not change spike number m^{-2}.

Grain number spike^{-1}: The result showed that genotypes were difference for grain number spike^{-1} ($p<0.01$) (Table 5). Nitrogen treatments changed grain number spike^{-1} in genotypes ($p<0.05$) (Table 5). FICC1329 and FICC0963 genotypes produced maximum grain number spike^{-1} (64 and 58 respectively) (Table 8). One hundred and twenty kg nitrogen ha^{-1} produced the most grain number spike^{-1} (50) (Table 10). The result is similar to previous report by Kabirian *et al.*[19]. High grain number spike^{-1} of FICC1329 and FICC0963 genotypes is due to high genetic potential and thousand-grain weight in these genotypes.

Genetic factors control fertile floret number spike^{-1}, but environmental condition also has effect on floret from pollination to grain maturity[26]. Thus, nitrogen fertilizer has positive effect on grain number spike^{-1}[27].

Harvest index: Genotype and plant population interaction effect on harvest index was significant at $p<0.01$ (Table 5). Highest harvest index was 40.32% for ALLISSO"S"/C103909-2 genotype at 500 plants m^{-2} and 39.15% for FICC1570 genotype at 300 plants m^{-2} (Table 7). High harvest index in FICC1570 genotype was related to its dwarf trait. High spike number and grain yield of ALLISSO"S"/C103909-2 genotype increased harvest index. Significant and positive correlation existed for harvest index with grain ($r = 0.74$), thousand grain weight ($r = 0.37$) and spike density ($r = 0.16$).

Grain protein percent and protein yield: Protein percent was not affected by any of treatments, but genotypes had different protein yield in different plant densities (Table 5). The most protein yield (58.48 g m^{-2}) was obtained at 500 plants m^{-2} (Table 9). Higher protein yield can be attributed to higher grain yield. Protein yield had positive correlation ($p<0.01$) with grain yield ($r = 0.906$), thousand-grain weight ($r = 0.206$) and spike density ($r = 0.639$). Although grain protein percent had not significant difference among genotypes but protein percent had negative and significant correlation ($p<0.01$) with grain yield ($r = -0.523$) and harvest index ($r = -0.652$).

CONCLUSIONS

Generally, high genetic diversity was observed among genotypes for grain yield and yield components. Nitrogen rate and suitable plant density are two important factors in high production. Therefore, the following cases were proposed as conclusion:

- Four genotypes had more grain yield under applied plant densities than others: ALLISSO"S"/C103909-2 had 5874 kg ha^{-1} grain yield at 500 plants m^{-2} plant density. FICC1570 had 4760 and 4510 kg ha^{-1} grain yield at 300 and 500 plants m^{-2} plant density, respectively.
- Three following genotypes had the most harvest index at mentioned plant densities: ALLISSO"S"/C103909-2 had 40.3% harvest index at 500 plants m^{-2}. FICC1570 genotype had 39.1% and FICC 1571 had 38.2% harvest index at 300 plants m^{-2}.
- FICC2712 genotype had 16.8% protein percent. ALLISSO"S"/C103909-2 had the most protein yield (64.8 g m^{-2}). FICC 1571 had the lowest protein percent (13.4%)

Therefore ALLISSO"S"/C103909-2 was the best genotype in respective of grain yield, harvest index and protein yield.

ACKNOWLEDGMENTS

The authors thank to Iran Seed and Plant Improvement Institute for providing the seeds of hulless barley and like to thank Mr. A. Salehi for his excellent technical assistance.

REFERENCES

1. Newman, R.K., S.E. Lewis, C.W. Newman, R.J. Boik and R.T. Ramage, 1989. Hypocholesterolemic effect of barley foods on healthy men. Nwtr. Rep. Intl., 39: 749-760.
2. Bhatty, R.S., 1986. The potential of hulless barley. A review. Cereal Chem., 63: 97-103.

3. Griffey, C., 1999. Hull-less barley as an improved feed crop. In: Small Grain Breeder. pp: 423-430.
4. Yang, W.Z., K.A. Beauchemin, B.I. Ferr and L.M. Rode, 1997. Comparison of barley, hulless barley and corn in the concentrate of dairy cows. J. Dairy Sci., 80: 2885-2895.
5. Hamid, Z.A. and J.E. Grafius, 1978. Developmental allometery and its implication to grain yield in barley. Crop Sci., 18: 83-86.
6. Riggs, T.J., P.R. Hanson and M.A. Ford, 1981. Comparison of spring barley varieties grown in England and Wales between 1880 and 1980. J. Agric. Sci., 97: 599-610.
7. Garcadel, M.L.T., J.M. Ramos and M.P. Jimenz, 1991. Ontogenetic approach to grain production in spring barley based on path coefficient analysis. Crop Sci., 31: 1179-1185.
8. Dofing, S.M., 1997. Ontogenic evaluation of grain yield and time to maturity in barley. Agron. J., 89: 685-690.
9. Mahler, R.L., F.E. Koehler and L.k. Lutcher. 1994. Soil and nitrogen source, timing of application and placement effects on winter wheat production. Agron. J., 86: 637-642.
10. Morgan, J.T. and L.J. Smith, 1996. Nitrogen in sugar beet taps and the growth of a subsequent wheat crop. Agron. J., 88: 521-526.
11. Fischer, R.A., G.N. Howe and Z. Ibrahim, 1993. Irrigated spring wheat and timing and amount of nitrogen fertilizer. I: Grain yield and protein content. Field Crops Res., 33: 37-56.
12. Frederick, J.R. and J.J. Camberato, 1995. Water and nitrogen effects on winter wheat in southeastern coastal plain I: Grain yield and kernel traits. Agron. J., 87: 521-526.
13. Campbell, C.A., F. Selles, R.P. Zenter and B.G. Mcconkey, 1993. Available water and nitrogen effects on yield components and grain nitrogen of zero till spring wheat. Agron. J., 85: 114-120.
14. Mossadeq, F. and D.H. Smith, 1994. Timing nitrogen application to enhance spring wheat yields in a Mediterranean climate. Agron. J., 86: 221-226.
15. Patel, P. and J. Patel, 1993. Effect of nitrogen levels and time of application with cutting system on yield and protein content of oats forage. Gujrat Agric. Univ. Res. J., 9: 142-145.
16. Anonymous, 1997. SAS/STAT user's guide, version 6, 4th Edn. SAS Inst., Cary, NC.
17. Steel R.g.d. and J.h. Torrie, 1998. Principles and Procedures of Statistics: a Biometric Approach. (Summerfield, R.g., A.h. Banting Eds.), pp: 17-36.
18. Qualset, C.O., C.W. Schaller and J.C. Williames, 1965. Performance of isogonics lines of barley as influenced by own length, linkage. Blocks and Environment. Crop Sci., 5: 489-494.
19. Kabirian, H.R., Y. Emam, M.T. Assad, H.Ghadiri and A.A. Komgar-Haghighi, 1998. Effect of planting density on yield and yield components of triticale in comparison to barley. Iran Agric. Res., 17: 35-50.
20. Grabinski, J., 1994. Growth, development and yield of winter triticale depending on depth and density of sowing and nitrogen fertilizer application. Zeszyty Naukowe Akademii Rolniczej. W. Szezecinic, Rolnictwo, 58: 49-54.
21. Piegh, M.L., S. Stankowski and M. Pozanski, 1990. Effect of sowing rate on yield and yield structure of winter triticale cv. Lasko. Biuletyn instytatu Hodowli Aklimatyzacji Roslin, 175: 15-23.
22. Stankowski, S., 1994. Reaction of spring triticale cultivated on light soil to sowing date, sowing rate, row spacing and sowing depth. Rozprawy-Akademia Rolhicza w. Szczecinie, 159: 71.
23. Siman, B., P.C. Struik, M.M. Nachit and J.M. Peacock, 1993. Ontogenetic analyses of yield components and yield stability of durum wheat in water- limited environment. Euphytica., 71: 211-219.
24. Mazurek, J., B.L. Jaskiewics and A. Sulek, 1987. Effect of sowing rate and row spacing on yield, yield components and germination of winter triticale cv. Lasko. Pamietnic Pulawski, 89: 6143-6154.
25. Anderson, W.K., 1984. Plant population for triticale in a Mediterranean environment. Field Crop Res., 8: 281-295.
26. Gallagher, J.N., P.V. Bisco and R.K. Scott, 1976. Barley and its environment. Stability of grain weight. J. Applied. Ecol., 12: 319-336.
27. Ayoub, M., S. Guertin, S. Lussier and D.L. Smith, 1994. Timing and level of nitrogen fertility effects on spring wheat yield in eastern Canada. Crop Sci., 34: 748-756.