American-Eurasian J. Agric. & Environ. Sci., 13 (3): 330-335, 2013
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2013.13.03.1940

Yield Performance Evaluation of Forage Barley under the Desert Conditions of Kuwait

H.S. Al-Menaie, H.S. Mahgoub, O. Al-Ragam, N. Al-Dosery, A. Al-Shatti, M. Mathew and N. Suresh

Arid Land Agriculture and Department of Greenery,
Kuwait Institute for Scientific Research P.O. Box: 24885, Safat 13109, State of Kuwait

Abstract: The combined effects of aridity and soil salinity limit the range of crops that can be cultivated in Kuwait and being a desert country, relies heavily on importation to meet the growing demand for forage. Kuwait Institute for Scientific Research (KISR), under the new strategic plan strives to develop modern agricultural technology to improve production performance of promising crops to meet food and forage demands. Hence, KISR initiated this activity to study the growth performance of forage barley genotypes under the harsh environmental conditions of Kuwait. 20 promising lines of barley were procured from Arab Center for the Study of Arid Zones and Dry Lands (ACSAD) and evaluated during two succeeding seasons 2008/2009 and 2009/2010 at the Agricultural Research Station, Sulaibya. The results revealed the significant effect on thousand grains weight and grain yield during the two seasons. Number of days to heading was differed significantly in each season which varied from 65 to 80 with an average of 73 days in the first season and from 73 to 91 days with average 83 days in the second season. There was a reduction in number of days to maturity by 7 days in the first season as compared with second season. During the second season, average plant height recorded was about 36% more compared to the first season. Grain yields were significantly different among the genotypes which ranged from 39.62 to 20.99 g in the first season and from 49.44 to 28.17 g in the second season. Number of grains per spike was more in the second season and it showed a 17% increase compared with that of the first season. Regarding the harvest index, the second season recorded an average increase of about 49% as compared to the first season. Further investigations need to be carried out to draw the final conclusions regarding the suitability of the selected lines under Kuwait's conditions.

Key words: Forage · Barley lines · ACSAD · Performance Evaluation

INTRODUCTION

Agriculture in the arid and semi-arid regions which remain unproductive due to the scarcity of water or salinity can be made possible by the use of drought and salt tolerant crop varieties and by implementing suitable planting techniques. To meet the growing demand for food and fodder, it is essential to increase production by even cultivating in non-productive saline soils [1]. Currently, Kuwait being a desert country, relies heavily on importation to meet the growing demand for forage. The combined effects of aridity and soil salinity limit the range of crops that can be cultivated in Kuwait, which results in the import of over 96% of its food [2]. It is essential to improve national food security in Kuwait by ensuring sustainability of agricultural production and conserving the scarce natural resources. In the new strategic plan KISR aims at developing modern agricultural technology to improve production performance of promising crops including forage species that have the potential as fodder crops.

The shortage of forage production in Kuwait has resulted in the inclusion of barley as a forage crop in the farming plans of farmers and is among the most dependable cereals under saline and drought conditions. Barley is considered to be relatively tolerant to alkaline

Corresponding Author: H.S. Al-Menaie, Arid Land Agriculture and Greenery Department,
Kuwait Institute for Scientific Research PO Box 24885, Safat 13109, State of Kuwait.
Tel: +965-24989806, Fax: +965-24989809.

soils, drought and extremes of temperature and also is classified as one of the most salt-tolerant crop species [3]. It is an important, versatile food and forage crop in dry areas and is also included in Kuwait's list of priority crops [4]. Barley plant can produce more biomass in a shorter time than any other cereal crop [5]. According to Al-Menaie *et al*. [6] and Al-Menaie [7], sustainable barley cultivation is feasible in Kuwait given careful consideration of soil type, local groundwater, soil rejuvenation, water table control and genotype. Hence, a study was conducted at Agricultural Research Station, Sulaibya to evaluate drought and salt-tolerant varieties of barley under the harsh conditions of Kuwait.

MATERIALS AND METHODS

Twenty exotic barley genotypes were procured from ACSAD (Arab Center for Studies of Arid Zones and Dry Lands) and evaluated during two successive seasons 2008/2009 and 2009/2010. The pedigrees of these genotypes are presented in Table 1. The field experiment was laid out in randomized complete block design [8] with three replicates.

Seed bed was prepared before sowing as recommended according to the package of practices. Organic fertilizers were applied at the rate of 40 m^3/ha and super phosphate (15.5%) at a rate of 35 kg P_2O_5/ha was added into the upper-15-cm layer of soil. Seeds were sown at the rate of 400 seeds /m^2. Experimental soil sites were divided into plots, the plot area is 3 m^2 (6 rows, 2.5 m long and 20 cm apart). Potassium (48-52% K_2O) was added in two equal doses at 1 and 2 Months after planting (at tillering and booting stages) at the rate of 55kg K/ha. Nitrogen fertilizer (Ammonium nitrate 33.5%N) added in ten equal doses before heading at the rate of 100 kg N/ha. All recommended cultural practices were adopted.

During growth period and pre-harvest, number of days to heading and maturity were recorded. Number of days to heading is the number of days from planting to the time of 50% of the shoots had entire spike showing above the flag leaf in each plots. Maturity date is denoted as the number of days from planting to the beginning of changing the color of main stem from green to yellow at 50% of plants in each plot. Plant height (cm) measured from soil surface to the top of the main spike excluding awns. Fertile spikes/m^2 was counted from each plot right before harvesting. Likewise, ten randomly selected main spikes were picked, threshed and their grains were counted. Their average was recorded to indicate number of grains per spike. At harvest, two external rows from each plot were eliminated to avoid the border effect. So, 4 rows were harvested, weighed, threshed and their grain yields were weighed and adjusted to t/ha to indicate the biological and grain yield. Likewise, a random sample of 1000 grains, taken from each plot was hand counted and weighed to indicate the kernel weight. Harvest index (HI) was measured by dividing grain yield by biological yield for each plot. The analysis of variance was performed for the two seasons and combined analysis of variance was conducted according to the standard procedures using SPSS statistical software.

Table 1: The Pedigree of the Twenty Barley Genotypes Used in this Study

No	Origin	Pedigree
1	ACSAD	Rihane-03//Lignee527/NK1272/5/Arizona5908/Aths//Avt/Attiki/3/s.t/Barley /4/Aths/Lignee640 ACS-B-11127(2000)-6IZ-1IZ-1IZ-0IZ
2	ACSAD	ER/Apm//AC253/3/Ath/Lignee686 ACS-B-11198(2001)-18IZ-1IZ-1IZ-0IZ
3	ACSAD	Rihane-03/7/Bda/5/Cr.115/Pro//Bc/3/Api/CM67/4/Giza120/6/DD/4/Rhn-03 ACS-B-11248(2000)-13IZ-2IZ-2IZ-0IZ
4	ACSAD	Rihane-03/4/Alanda//Lignee527//Arar/3/Centinela/2*Calicuchima ACS-B-11245(2001)-9IZ-2IZ-1IZ-0IZ
5	ACSAD	ACSAD1182/4/Alanda//Lignee527//Arar/3/Centinela/2*Calicuchima ACS-B-11265(2001)-5IZ-2IZ-1IZ-0IZ
6	ACSAD	ACSAD1182/4/Alanda//Lignee527//Arar/3/Centinela/2*Calicuchima ACS-B-11265(2001)-13IZ-1IZ-2IZ-0IZ
7	ACSAD	ACSAD1182/5/Apm/HC1905//Robur/3/Arar/4/Apm/HC1905//Robur/3/Arar ACS-B-11266(2001)-1IZ-2IZ-1IZ-0IZ
8	ACSAD	ACSAD1468//Aths/Lignee686 ACS-B-11281(2001)-12IZ-1IZ-1IZ-0IZ
9	ACSAD	Alger/Ceres//Sls/3/Er/Apm/4/W12197/Mazurka/5/Sutter*2/Numar//P386540 ACS-B-11314(2002)-8IZ-2IZ-1IZ-OIZ
10	ACSAD	Alger/Ceres//Sls/3/Er/Apm/4/W12197/Mazurka/5/ACSAD1474 ACS-B-11327(2002)-11IZ-1IZ-1IZ-OIZ
11	ACSAD	Hml//Hml-02/Arabi Abiad*2/3/Furat2 ACS-B-11355(2002)-3IZ-2IZ-1IZ-OIZ
12	ACSAD	Hml//Hml-02/Arabi Abiad*2/3/Furat2 ACS-B-11355(2002)-10IZ-2IZ-1IZ-OIZ
13	ACSAD	Hml//Hml-02/Arabi Abiad*2/3/Furat2 ACS-B-11355(2002)-20IZ-2IZ-1IZ-OIZ
14	ACSAD	Cerise/Lignee1479//Moroc 9- 75/PmB/4/Lignee527/Nk1272/3/Nachja2//Lignee640/Harma-01 ACS-B-11362(2002)-25IZ-1IZ-1IZ-OIZ
15	ACSAD	Cerise/Lignee1479//Moroc 9-75/PmB/3/ACSAD1470 ACS-B-11371(2002)-14IZ-1IZ-1IZ-OIZ
16	ACSAD	Cerise/Lignee1479//Moroco 9-75/PmB/3/ACSAD1470 ACS-B-11371(2002)-14IZ-2IZ-1IZ-OIZ
17	ACSAD	Er/Apm/3/Arr/Esp//Alger/Ceres362-1-1/4/Cam/B1//CI08887/CI0576/5/AXSAD 1474 ACS-B-11399(2002)-27IZ-1IZ-OIZ
18	ACSAD	Aths/Lignee686//Orge 905/Cr289-53-2/4/Lignee527//Nk1272/3/Nacha2//Lignee 640/Harma-01 ACS-B-11401(2002)-15IZ-2IZ-1IZ-OIZ
19	ACSAD	Aths/Lignee686//Orge 905/Gr289-53-2/8/Mo.B1337/W12291/7/Sls/6/Pld 10342//Cr.115/Por/3/Bahtim9/4/Ds/Apro/5/W12291 ACS-B-11403(2002)-24IZ-2IZ-1IZ-OIZ
20	ACSAD	Local Check

RESULTS AND DISCUSSION

The combined analysis of variance for data obtained from the two seasons 2008/2009 and 2009/2010 are presented in Table 2. The results revealed a significant effect for seasons on thousand grains weight (TGW) and grain yield, indicating that response of these characters were different from in the two seasons. Moreover, the effect of the interaction between seasons and cultivars were significant for all characters except 1000 kernel weight.

The temperature recorded during the period of study is illustrated in Fig. 1. The minimum temperature recorded during 2008-2009 was higher than that of 2009-2010. This might have caused reduction in the number of spikes per unite area. The maximum temperature was higher in May 2010 and high temperatures during filling period might have caused yield reduction due to accelerated senescence [9].

Days to Heading: Number of days to heading differed significantly in each season among the different genotypes. It varied from 65 to 80 with an average of 73 days in the first season and from 73 to 91 days with average 83 days in the second season (Table 3). This difference may be due to the sensitivity of different genotypes to photoperiod and vernalization [10].

Days to Maturity: There was a reduction in number of days to maturity by 7 days in the first season as compared with the second season. Line 18 and Line 1 (96 and 99) were earlier in maturity. Meanwhile, Line 9 is the latest (121) in the first season. On the other hand, there is no significant difference between genotypes in the second season for the days to maturity. This may due to the response of genotypes to avoid heat stress during grain filling period.

Plant Height: Data showed highly significant difference among the genotypes for plant height in the two seasons. During the second season, average plant height recorded was about 36% more compared to the first season (Table 3). During the first season, the highest plant height was recorded for Line 3 (81.53cm) and the local variety recorded the lowest value of 56.84. During the second season, the highest plant height was recorded in Line 2 (107.63cm) and the shortest was obtained in Line 14. The lowest plant height was observed in the first year may due to the highest minimum temperatures during the growth stage, which might have caused the increase in respiration rate and decrease in the accumulation of carbohydrate.

Grain Yields: Grain yields were significantly different among the genotypes in both seasons. The grain yield during the first season was reduced by about 51% as a compared to the second season. During the first season, Line 19 was superior in grain yield (1.29 t/ha) compared to the lines 11, 17, 6, 5, 3, 12, 8 and the local cultivar recorded the lowest grain yield (Table 4). During the second season, Line 1 has the highest grain yield (2.15 t/ha) compared to the lines 18, 5, 2, 11, 6, 9, 8, 7 and 3. Fourteen genotypes were superior in their grain yield as a compared with local variety. The reduction in grain yield in the first season might be due to the high temperature during heading and filling period. Results reported that heat stress occurred during anthesis and grain filling periods had negative influenced the movement of photosynthetic products to the developing grains and inhibited starch synthesis resulting in lower grain weight [11, 12].

Number of Spikes per Square Meter: Number of spikes per unit area is an important character which affects highest yield. During the first season, the highest number of spikes was recorded in Line 11 without significant difference with 17, 19, 6, 3 and 5, while the lowest number was obtained in Line 4 (128). During the second season number of spikes was increased about 12%. The highest number of spikes was obtained in Line 11 (468) without significant difference with Lines 7, 14 and 12. The reduction in number of spikes during the first season might be due to the higher minimum temperatures as a compared to the second season (Fig 1).

Thousand Grains Weight: The weight of grains ranged from 39.62 to 20.99 gm in the first season and from 49.44 to 28.17 gm in the second season. The genotype with more

Table 2: Summary of ANOVA for Different Characters Affected by Barley Cultivars Over Two Seasons

Source of variation	D.H	D.M	FP	PH	TGW	Sp/m^2	NG/S	GY	ST	HI
Seasons (s)	*	**	--	**	**	--	--	**	--	**
Cultivars (V)	**	**	**	**	**	**	**	**	*	**
S x V	**	**	**	**	--	**	**	**	**	**

TGW → Thousand grains weight Sp/m^2 → number of spikes per square meter NG/S → number of grains per spike Gy → Grain yield (t/ha)

ST → Straw yield (t/ha) HI → Harvest index = (Grain yield/ straw yield)*100 ** → significant at 99% * → significant at 95% -- → Non significant

Table 3: Comparative performance of twenty barley genotypes for days to heading and maturity and plant height in 2008/2009 and 2009/2010 seasons

	Days to heading		Days to maturity		Plant height	
Cultivars	S1	S2	S1	S2	S1	S2
Line 1	73	73	99	116	63.24	107.03
Line 2	78	84	104	117	63.50	107.63
Line 3	72	86	111	117	81.53	104.47
Line 4	74	77	111	117	71.00	96.93
Line 5	74	77	110	116	62.80	98.57
Line 6	80	88	112	117	70.27	94.07
Line 7	73	74	112	116	63.90	100.67
Line 8	69	85	117	117	64.27	80.70
Line 9	79	86	121	118	66.13	94.57
Line 10	65	91	114	117	68.13	82.67
Line 11	72	75	112	117	70.47	76.53
Line 12	72	85	111	116	72.13	77.17
Line 13	66	79	111	116	69.00	95.27
Line 14	74	89	111	117	70.93	74.43
Line 15	74	91	112	118	71.73	105.27
Line 16	73	86	115	117	72.00	84.23
Line 17	67	87	112	116	71.80	93.90
Line 18	75	74	96	118	65.60	92.60
Line 19	69	86	110	117	65.40	92.33
Local variety	73	87	108	118	56.84	89.10
Mean	73	83	110	117	68.03	92.41
L.S.D 0.05	10	6	4	--	11.14	15.69

Table 4: Comparative performance of twenty barley genotypes for yield, yield components and harvest index in 2008/2009 and 2009/2010 seasons

	GY		Sp/m^2		TGW		NG/S		ST		HI	
Cultivars	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Line 1	0.53	2.15	257	327	32.60	47.18	34	40	3.55	2.54	13	46
Line 2	0.52	2.00	282	320	32.10	40.25	22	42	2.73	2.40	16	45
Line 3	0.89	1.54	358	342	29.35	39.42	25	45	3.93	2.59	20	37
Line 4	0.70	1.45	125	195	27.12	37.96	31	39	4.23	3.00	14	32
Line 5	0.98	2.00	355	375	28.15	38.59	40	41	3.83	2.79	21	42
Line 6	0.99	1.77	360	277	37.55	40.36	28	32	3.17	3.62	24	34
Line 7	0.35	1.65	340	423	26.09	35.10	39	42	2.00	2.87	15	37
Line 8	0.83	1.71	325	343	26.27	37.03	39	25	3.20	2.57	20	41
Line 9	0.74	1.74	270	233	24.64	35.36	21	37	2.97	2.72	20	40
Line 10	0.61	0.85	253	223	20.99	28.17	33	29	2.10	3.28	23	21
Line 11	1.28	1.97	433	468	38.48	35.38	24	30	4.65	2.32	23	46
Line 12	0.84	1.20	307	410	35.29	49.44	23	20	4.25	2.98	19	29
Line 13	0.45	1.47	243	360	34.38	34.91	31	33	3.33	2.78	12	34
Line 14	0.59	0.67	212	420	32.57	41.44	19	12	2.47	3.09	19	18
Line 15	0.46	0.84	205	295	25.02	31.08	20	49	2.70	3.22	15	20
Line 16	0.68	1.45	200	343	31.15	46.72	26	24	2.73	2.59	21	35
Line 17	1.23	1.48	415	328	22.23	28.36	36	41	3.65	2.95	25	34
Line 18	0.52	2.08	213	265	29.87	30.29	42	42	3.05	2.16	13	49
Line 19	1.29	0.91	375	303	25.41	30.09	26	37	3.15	2.28	22	28
Local variety	0.27	1.25	290	335	39.28	43.22	29	31	3.17	2.21	7	34
Mean	0.74	1.51	291	329	29.93	37.52	29	35	3.24	2.75	18	35
L.S.D 0.05	0.45	0.48	15	14	1.35	1.35	2	3	0.19	--	2	2

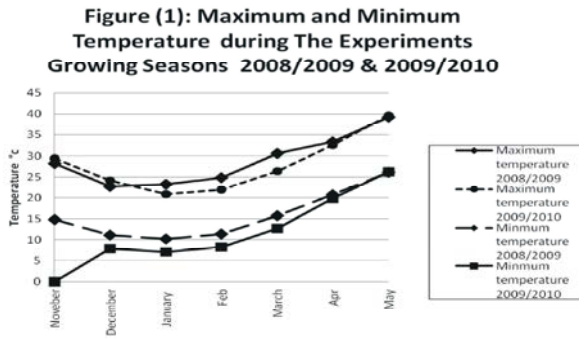

Fig. 1: Temperature status during the experiments

thousand grain weight had positive effect on higher grain yield and showed a negative effect with the number of spikes per square meter.

Number of Grains per Spike: Number of grains per spike was more in the second season and it showed a 17% increase compared with that of the first season. High temperatures during flowering can negatively affect flowering and subsequently seed set and hence earlier flowering genotypes avoids the heat than late flowering one.

Straw Yield: Straw is one of the most important sources of feeds for sheep. Statistical analysis of data revealed that straw yield was significantly higher during the first season. The maximum straw yield was recorded in line 11 (4.75 t/ha) and the minimum of 2 tons/ hectare) was recorded in Line 7 which might be due to the reduced number of tillers.

Harvest Index: Data obtained showed highly significant differences among genotypes for the two seasons for harvest index. The second season recorded an average increase of about 49% as compared to the first season (Table 4). Selection for harvest index should increase grain yield particularly when biological yield relatively stable.

CONCLUSION

20 promising lines of barley procured from Arab Center for the Study of Arid Zones and Dry Lands (ACSAD) were evaluated during two succeeding seasons 2008/2009 and 2009/2010 at the Agricultural Research Station, Sulaibya and found to be suitable under the climatic conditions of Kuwait. Statistical analysis of the results revealed the significant effect on thousand grains weight (TGW) and grain yield during the two seasons. Number of days to heading differed significantly in each season among the different genotypes. Regarding plant height, during the second season, average plant height recorded was about 36% more compared to the first season. Grain yields were significantly different among the genotypes in both seasons. Number of grains per spike was more in the second season and it showed a 17% increase compared with that of the first season. The second season recorded an average increase of about 49% on harvest index as compared to the first season. Further investigations need to be carried out to draw the final conclusions regarding the suitability of the selected lines under Kuwait's conditions.

ACKNOWLEDGEMENT

The author thanks the management of the Kuwait Institute for Scientific Research and the Kuwait Foundation for the Advancement of Sciences for their continued interest, encouragement and financial support to this activity.

REFERENCES

1. Dagar, J.C., 2009. Opportunities for Alternative Land Uses in Salty and Water Scarcity Areas. International Journal of Ecology and Environmental Sciences, 35(1): 53-56.
2. Encyclopedia of the Nations. 2005. Available at http://www.nationsencyclopedia.com/economies/ Asia and the Pacific/ Kuwait. Accessed on July 30, 2012.
3. ICARDA, 2000. Germplasm program- barley germplasm improvement for increased productivity and yield stability. International Center for Agricultural Research in the Dry Areas, Aleppo, Syria.
4. Levitt, J., 1980. Responses of plants to Environmental Stresses. 2nd Ed. Vol. 1. Chilling, Freezing and High Temperature Stresses. New York, NY: Academic Press, New York.
5. Miller, P.R. WL. Graves, W.A. Williams and B.A. Madson. 1989. Cover Crops for California Agriculture. University of California, Sustainable Agriculture Research and Education Program, Division of Agriculture and Natural Resources. Davis, California, US.

6. Al-Menaie, H.S., P.D.S. Caligari and B.P. Forster. 2004. Matching soil, water and genotype for barley cultivation in Kuwait. In the Proceedings of the 9th International Barley Genetics Symposium, Brno, Czech Republic, pp: 7-11.
7. Al-Menaie, H.S., 2003. Matching soil, water and genotype for barley cultivation in Kuwait. PhD thesis, University of Reading, Reading, UK.
8. Gomez, K.A. and A.A. Gomez, 1983. Statistical Procedures for Agricultural Research. 2nd Ed. John Wily and Sons, New York.
9. Al-Khatib, K. and G.M. Paulsen, 1984. Mode of high temperature injury to wheat during grain development. Plant Physiology, 61: 363-368.
10. Slafer, G.A. and H.M. Rasuson, 1995. Photoperiod x temperature interaction in contrasting genotypes, time to heading and final leaf number. Field Crops Res., 44: 73-83.
11. Garíadel, M.L.F., Y. Rharrabti, D. Villegas and C. Royo, 2003. Evaluation of grain yield and its components in durum wheat under Mediterranean conditions: an ontogenic approach," Agronomy Journal, 95(2): 266-274.
12. KISR. 1996. Agricultural Master Plan of the State of Kuwait (1995-2015): Plan overview. Kuwait Institute for Scientific Research, Kuwait.