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Impact of Fertilizer and Herbicide Application on Performance of Ten Barley Genotypes Grown in Northeastern Part of Jordan

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ABSTRACT

Field trials were conducted at Jordan University of Science and Technology campus (JUST) in northeastern part of Jordan during 1997/98, and 1998/99 growing seasons. Ten barley genotypes were evaluated for grain yield and yield components in response to fertilization and herbicide applications. A split block design was used with three replications. Genotypes were randomly assigned to plots within blocks. The combinations of fertilizer and herbicide application were applied in strips across the genotypes. Grain yields were greater in the first growing season compared to the second growing season. Highest grain yields, spikes m^{-2}, and grains $spike^{-1}$ were recorded with fertilizer application in both growing seasons, but it was not affected with herbicide applications The Baladi barley and Rum genotypes gave significantly highest, spikes m^{-2} and grain yield than other genotypes tested in both growing seasons. In any treatment combinations and growing season Rum genotype produced significantly heavier grain weight than other genotypes. Application of 100Kg ha^{-1} (diammonium phosphate) and 50 kg ha^{-1} urea as top dressing is recommended for producing higher grain yield by all genotypes. While application of broad leaf herbicide was not critical.

Key Words: Barley; Herbicide; Fertilizer; Grain Yield

INTRODUCTION

Barley (*Hordeum vulgare* L.) is an important winter crop in the drier, predominantly rain-fed areas of West Asia and Africa (Tawaha *et al*., 2003). More than 80% of the total land area of Jordan receives less than 200 mm rainfall (7.27 million ha) and it is called Badia region (Department of Agriculture Statistics, 1994). Under stresses, such as drought and cold, the yield of barely is much higher than that of oat, wheat, or rye (Chapman & Carter, 1976). The grain yield of barley was low (770 kg ha^{-1}) which is far below the international figures of 2606 kg ha^{-1} (Department of Agriculture Statistics, 1996). To meet the increasing demand of animal feeds Jordan imports annually an average of 283 ton (Department of Agriculture Statistics, 1996). Barley grain is used as feed, food, and for malting purposes, while barley straw provides an important source of roughage (Al-Jamali *et al.,* 2002; Tawaha & Turk, 2002; Tawaha *et al*., 2002; Turk & Tawaha, 2002, 2003; Tawaha *et al*., 2003; Turk *et al*., 2003).

Increasing barley production could decrease importing animal feed. The low productivity of barley in Jordan are due to wide seasonal variability, low amount of rainfall, poor soil moisture conservation and preparation practices, the lack of crop rotation, poor stand resulting from lack of weed control, and with low yield potential genotypes (Tawaha *et al*., 2001, 2002, 2003; Turk & Tawaha, 2001, 2002, 2003; Al-Jamali *et al*., 2002; Tawaha & Turk, 2002; Turk *et al*., 2003)**.** Only minor areas of rainfed barley crop currently receives fertilizers. Farmers realized that rainfall is the main limiting growth factor, and fertilizer is likely to be ineffective if not counter for barley production. However, results of the Mashreq project have demonstrated the opposite. Seedbed fertilizers, particularly phosphate, stimulate early growth and development, and increased water use efficiency (Jaradat & Haddad, 1994). Soil analysis have shown that phosphate deficiency is widespread in the calcareous soils which comprise over half of the total cultivated areas of the Mediterranean region (Kassam, 1981). Field trials conducted on these soils have demonstrated economic responses to phosphate fertilizers (Turk, 1998). Phosphorus fertilizers are widely used in the Mediterranean region for wheat production and the phosphorus requirements for wheat are relatively well established. In contrast to wheat farmers, barley farmers under rainfed condition use less than optimum rates of N and P, because of the low annual rainfall and the uncertainties associated with rainfall. Barley may need less fertilizer than wheat, but to increase productivity, chemical fertilizers should be used (Al-Rawi, 1990). Traditional culture practices in the barley-based farming system of Jordan have been modified as a result of previous research efforts.

New practices have been developed in the aspects of tillage, fertilizer application, using improved genotypes, and herbicides. Farmers were encouraged to adopt a newly developed package of practices for barely production, in order to improve the productivity. It is difficult for many farmers in Jordan to adopt the full package recommended in barley production. However, research results, obtained by the national program indicated that the use of improved genotypes and fertilizers would result in substantial yield increase. Other components of the full package might not be as critical.

The present study was designed to evaluate ten promising barley genotypes and to investigate the potentiality of these genotypes in respect to using fertilizers and herbicides. The objectives of this study were to (i) Evaluate ten barely genotypes for grain yield and their components, (ii) Investigate the response of these genotypes to DAP fertilizer (Diammonium phosphate 18% N and 46% P_2O_5), and (iii) Study the effect of using 2, 4-D (2, 4-Dichlorophenoxy acetic acid) on grain yield and yield components.

MATERIALS AND METHODS

Site description. Field trials were carried out at Jordan University of Science and Technology campus (JUST) in the Northeastern part of Jordan (32° 34' N latitude, 36° 01''´E longitude, and 520 m altitude) during the two growing seasons of 1997/98, and 1998/99.The location has Mediterranean climate of mild rainy winters and dry hot summers. The soil is silty clay loam.

Experimental design and treatments. A split block design was used with three replications. Genotypes were randomly assigned to plots within blocks. The combinations of fertilizer and herbicide application were applied in strips across the genotypes.

Fertilizer – herbicide combinations were, (i) control (F0H0), (ii) fertilizer and zero herbicide (F1H0) consisting of two applications: granular fertilizer DAP (diammonium phosphate 18% N and 46% P_2O_5) 100kg ha^{-1} at sowing. In addition to that 50 Kg ha^{-1} of Urea (46% N) was added at tillering stage as a top-dressing, (iii) zero fertilizer and herbicide (F0H1): the herbicide 2,4-D (2, 4-dichlorophenoxy acetic acid) ester was applied at a rate of 84 g ha^{-1} (a.i), when the barley genotypes reached 15-20 cm in height (tillering stage) and most of weeds have germinated in both seasons to control broad leaved weeds, and, (iv) fertilizer and herbicide (F1H1).

Crop management. The seeds were sown by hand at a seeding rate of 130 kg ha^{-1} on 10th Dec. 1997, and 2nd Jan., 1999. The trial was irrigated by an amount of 50 mm within in once the second growing season after the first ineffective rainfall. Plants were harvested at maturity on June 8, and June 20, in 1997/98 and 1998/99 growing seasons, respectively. From the three central rows of each plot, plants in one m^2 quadrat were clipped at 10 cm above the soil surface by hand sickle.

Genotypes. Ten barley genotypes were selected because of their adaptation to the dry land production and demonstrated good yield performance in previous years (Table I).

Data Recorded. In both growing seasons, the following measurements on: number of spikes m^{-2}, grain yield, number of grains per spike, thousand-grain weights were made.

Statistical analyses. The analysis of variance and mean separation were performed using computer statistical program MSTAT-C as described for a split - block design by Steel and Torrie (1980). Comparisons between means were made using the least significant difference test (LSD) at 0.05 probability level.

RESULTS AND DISCUSSION

The effect of, 2, 4-D (2, 4-dichlorophenoxy acetic acid) ester, DAP (diammonium phosphate 18% N and 46% P_2O_5) applications and genotypes on yield and yield components were studied at JUST during 1997/98 and 1998/99 growing seasons. The effect of the two factors was investigated on: number of spikes m^{-2}, grain yield, number of grains per spike and thousand-grain weight.

Data collected for all characters were subjected to statistical analysis of variance to detect significant differences among treatments (i.e., fertilizer -herbicide application and barley genotypes). The main effects were considered in the absence of significant interactions between treatments and genotypes. The analyses of variances for yield and yield components, are summarized in Table II. The data presented are the results of F-tests performed to examine main and interactive effects.

Rainfall distribution. The precipitation during 1997-98 growing season was higher than 1998-99. The total annual precipitation was 292 mm during 97-98 growing season compared to 108 mm during 98-99 growing season. Rainfall during the second growing season was about 2.5 folds lower than the first growing season and the decrease was reflected in lower grain yield.

Yield and Yield Components

Number of spikes m^{-2}. Significant differences ($P \leq 0.05$) in number of spikes m^{-2} were recorded between the genotypes during both growing seasons (Table III). In the first growing season, the Baladi barley gave the highest number of spikes m^{-2} (308.2), but it was not significantly different from Rum and CWB117-77-9-7//Alpha /Durra, (274.9 and 256.3 spikes m^{-2}, respectively). However, Lokus /Sls gave the lowest number of spikes per m^{-2} (141.4), but it was not significantly different from Rihane and Salmas their numbers of spikes m^{-2}were 151.8 and 178.8, respectively. In

Table I. Names, pedigree and source of the barley genotypes

Genotypes	Pedigree	Source
Roho// Alger// Ceres 362-1-1/3/Tipper	ICBH89-0157-1AP-0AP-5AP-0AP	ICARDA*
Wieselburgre/Ahor 1303-61//Sls.	ICBH89-0135-20AP-0AP-3AP-0AP	ICARDA
Rihane		ICARDA
CWB117-77-9-7/Grivita	ICBH90-0039-5AP-0AP-1AP-0AP	ICARDA
CWB117-77-9-7// Alpha/Durra.	ICBH90-0022-0AP-2AP-0AP-5AP-0AP	ICARDA
Salmas		ICARDA
Lokus /Sls/.	ICBH89-0313-5AP-0AP-2AP-0AP	ICARDA
Rum	Harbin-Arivat x Attik	NCARTT**
ACSAD 176	(CMB72´?´-189-3Y-1B-2Y-1B-x1Y-OB) x(Cr.366/16/2)	NCARTT
Baladi barley***		Local farm

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** National Center for Agriculture Research and Technology Transfer (NCARTT), Jordan

Table II. Summary of main and interactive effects on yield and yield components for ten barley genotypes

Trait	1997/1998			1998/1999		
	Genotype	Treatment	Interaction	Genotype	Treatment	Interaction
Spike m^{-2}	*	*	NS	*	*	NS
Grain yield(kg ha^{-1})	*	*	NS	*	*	NS
Grain $spike^{-1}$	*	*	NS	*	*	NS
1000 grain weight (g)	*	*	*	*	*	*

* and NS, Significant and not significant respectively at($P \leq 0.05$); - Data was not collected

Table III. Effect of treatments and genotypes on number of spikes m^{-2}, grain yield, number of grains per spike of ten barley genotypes

Genotypes	Number of spikes (m^{-2})		Grain yield (kg ha^{-1})		Grains per spike	
	1997/1998	1998/1999	1997/1998	1998/1999	1997/1998	1998/1999
Roho//Alger//Ceres 362-1-1/3/ Tipper	227.7	183.6	1016	761	22.2	19.5
Wieselburger/Ahor 1303-61//Sls	218.1	172.8	943	655	20.6	17.2
Rihane	151.8	125.2	791	491	25.0	25.8
CWB117-77-9-7/Grivita	202.8	159.8	898	657	21.3	15.4
CWB117-77-9-7//Alpha /Durra	256.3	200.8	1140	1006	23.8	17.1
Salmas	178.8	142.7	854	500	18.3	15.1
Lokus/Sls.	141.4	107.0	719	499	27.3	26.2
Rum	274.9	218.7	1259	933	25.2	23.1
ACSAD 176	243.8	197.6	1089	932	24.6	21.2
Baladi barley	308.2	244.7	1290	1023	26.6	30.5
Mean	220.4	175.3	1000	746	23.5	21.1
LSD($P \leq 0.05$)	55.3	29.7	149	132	2.4	4.0
*Treatment						
F0H0	197.4	158.0	888	564	20.6	19.4
F0H1	178.9	142.4	720	483	20.1	17.5
F1H0	265.1	211.5	1251	1058	27.8	25.2
F1H1	240.0	189.2	1141	878	25.4	22.3
LSD($P \leq 0.05$)	19.9	19.8	123	77	2.3	4.4

*Control (F0H0), Fertilizer and zero herbicide (F1H0), Zero fertilizer and herbicide (F0H1), Fertilizer and herbicide (F1H1).

the second growing season, the Baladi barley gave the highest number of spikes m^{-2} (244.7), which was not significantly different from Rum (218.7). The lower producer genotype continue to be Lokus /Sls its number of spikes m^{-2} was (107.0), which was not significantly different from Rihane number of spikes m^{-2} was (152.2). Differences in number of spike m^{-2} between genotypes were probably related mainly to the differences in their genetic potential.

For overall genotypes, the average number of spikes $^{-2}$ during the first growing season (308.2) was higher than that obtained in the second growing season (244.7). This could be related to drought conditions during the second growing season. This agrees with the findings for Dubetz and Wells (1965) where reported that this component showed the greatest response to available soil water in barley. The positive effect of fertilizer application on number of spikes m^{-2} hugely was significantly higher when fertilizers were applied (Treatment F1 in Table III). Similar results were reported by Power and Alessi (1978) who found that nitrogen application to barley increased number of spike m^{-2}.

The highest number of spikes m^{-2} was recorded when fertilizer was applied with no spraying of herbicide (Treatment F1H0) in both growing seasons (265.1 and 211.5 spikes m^{-2}, respectively). On the other hand, the lowest number of spike m^{-2} was recorded when no fertilizer was applied with or without herbicide application (Treatments F0H1, and F0H0) in both growing seasons.

Grain yield. Significant differences ($P \leq 0.05$) in grain yield were recorded between the genotypes studied during both growing seasons (Table III). In the first growing season, the Baladi barley gave the highest grain yield (1290 kg ha^{-1}), but it was not significantly different from Rum (1259 kg ha^{-1}). However, Lokus /Sls gave the lowest grain yield (719) kg ha^{-1}which was not significantly different from Rihane and Salmas (791 and 854 kg ha^{-1}, receptively). In the second growing season, the Baladi barley was again the highest producing genotype (1023 kg ha^{-1}), which was not significantly different from CW117-77-9-7//Alpha/Durra, Rum, and ACSAD 176 (1006, 933 and 932 kg ha^{-1}, respectively). The lower producing genotypes continued to be Rihane, Lokus /Sls and Salmas and their yields were 491, 499, and 500 kg ha^{-1}, respectively. The variation was attributed to the differences in genetic potential among genotypes.

First growing season gave a higher grain yield than the second growing season. This reduction was mainly due to low rainfall. This again can be explained by higher and better distribution of rainfall during the first growing season which made the nutrients more available to plants throughout different growth stages. This result was consistent with Turk (1998) who found that reduction in rainfall was reflected on lower grain yield. Grain yield was significantly higher when fertilizer was applied (Treatment F1). This was due primarily to increased number of spike m^{-2} (Table III) and increased number of grains per spike (Table III). Fertilizer significantly increased grain yield. Similarly, Turk (1998) revealed that higher grain yield of several barley genotypes were obtained by increasing nitrogen and phosphorus levels. Nitrogen fertilizer reduced tiller mortality, particularly for the highest order tillers providing; more spikes ha^{-1} and subsequently greater grain yield (Power & Alessi, 1978). On the contrary, grain yield in both growing seasons, were not affected with herbicide applications.

Number of grains spike^{-1}. Significant difference ($P \leq 0.05$) in number of grains per spike was recorded between the genotypes during both growing seasons (Table III). In the first growing season, the Lokus/Sls gave the highest number of grains per spike (27.3), but it was not significantly different from Baladi barley and Rum, where the values were 26.6 and 25.2, respectively. However Salmas gave the lowest number of grains per spike (18.3) which was not significantly different from Wieselburger/ Ahor 13030-61//Sls in which number of grains per spike was (20.6). In the second growing season, the Baladi barley gave the highest number of grains per spike (30.5) and Salmas continued to be lower producing genotype (15.1) was not significantly different from CWB117-77-9-7/Grivita, CWB117-77-9-7//Alpha/Durra and Weiselburger/Ahor 1303-61//Sls.These results were expected because of genetic makeup of barley genotypes.

Overall, the average number of grains per spike during the first growing season (23.5) was higher than that obtained in the second growing season (21.1) grains spike^{-1}. This could be related to the drought conditions during the second growing season been reported by EL-Nadi (1970).

Number of grains per spike was significantly higher when fertilizers were applied (Treatment F1 in 1997/98, Table III). This finding is supported by Brown *et al.* (1982) who found that number of barley grains per spike increased with fertilizer application.

Herbicide application did not reduce number of grains per spike, the lowest number of grains per spike, was with the application of herbicide (Treatment H1 in Table III). These results are supported by the finding of Martin *et al.* (1990) who found that herbicide application did not reduce number of wheat grains per spike. The highest numerical number of grains per spike was obtained when fertilizers were applied with no spraying of herbicide (Treatment F1H0) in both growing seasons (23.8 and 25.2 grain spike^{-1}, respectively). On the other hand, the lowest numerical number of grains per spike was recorded when herbicide was sprayed with no fertilizer added (Treatment F0H1) in both growing seasons (20.1 and 17.5 grains spike^{-1}, respectively).

1000-grain weight. Significant interactions occurred ($P \leq 0.05$) between treatments and genotypes during both growing season (Table IV). The Rum genotype produced significantly heavier grains than other genotypes in response to herbicide and fertilizer treatments in both growing seasons. This may be owing to larger grain size of Rum genotype. In addition, 1000-grain weight is a genotype characteristic under certain condition. In the first growing season, Rum genotype produced significantly higher grain weight when herbicide was sprayed and no fertilizer was added (Treatment F0H1). These results were in agreement with those reported by

Table IV. Effect of treatments and genotypes interactions on 1000-grain weight (g) of ten barley genotypes

Genotypes	*Treatments							
	1997/1998				1998/1999			
	F0H0	F0H1	F1H0	F1H1	F0H0	F0H1	F1H0	F1H1
Roho//Alger//Ceres 362-1-1/3/ Tipper	28.3	30.3l	23.7	24.2	25.6	26.0	22.1	20.9
Wieselburger/Ahor 130361//Sls	27.7	28.5	23.9	26.4	29.5	22.7	25.4	22.1
Rihane	32.9	33.3	26.4	26.8	32.7D	28.7	27.3	26.7
CWB117-77-9-7/Grivita	21.7	25.3	20.9	18.4	22.7	23.0	22.3	21.3
CWB117-77-9-7//Alpha /Durra	22.2	23.0	19.3	19.7	20.7	19.7	19.7	20.3
Salmas	30.8	32.6	30.2	29.6	31.3	28.3	27.3	30.7
Lokus/Sls.	22.5	22.5	18.1	20.5	22.3	21.3	19.7	18.1
Rum	37.3	39.4	38.1	38.2	37.7	35.3	33.7	33.3
ACSAD 176	36.3	36.3	32.2	36.9	32.0	33.7	32.7	31.1
Baladi barley	34.6	34.8	32.6	32.9	32.7	33.3	30. 0	28.3
LSD($P \leq 0.05$)	0.3				0.8			

*Control (F0H0), Fertilizer and zero herbicide (F1H0), Zero fertilizer and herbicide (F0H1), Fertilizer and herbicide (F1H1).

Ahmed *et al.* (1993) who found that herbicide application increased 1000-grain weight. However, CWB117-77-9-Alpha/Durra produced the lowest grain weight when fertilizer was applied with no spraying of herbicide (Treatment F1H0). In the second growing season, Rum genotype produced significantly higher grain weight when no herbicide was sprayed and no fertilizer was added (Treatment F0H0). However, CWB117-77-9-Alpha/Durra produced the lowest grain weight when fertilizer was applied with no spraying of herbicide. These results were in agreement with those reported by Reisenauer and Dickson (1961) who found that nitrogen application reduced 1000-grain weight of barley. Greater 1000-grain weights were recorded in the first season in comparison to the second growing season; average being 28.6 and 26.7g, respectively. This may be attributed to better environmental conditions were excellent during first growing season. Water stress during booting stage was most sensitive to moisture and resulted in reduction of 1000 grain weight. The results of this study were in agreement with those reported by Abu-shriha (1989) who found that water stress during booting stage reduced 1000-grain weight.

CONCLUSIONS

This paper demonstrates great scope for improving barley production in Northeastern part of Jordan as well as in the West Asia and North Africa, where similar environmental conditions are prevailing. The major constraint to enhance barley yield is lack of agronomic management technology suited to varying conditions under which the crop is grown. Input management, furthermore, is almost unknown to Jordanian barley farmers. As recent researches show, however, application of 100 kg (diammonium phosphate 18% N and 46% P_2O_5) at sowing time and 50 kg ha^{-1} urea (46% N) at tillering stage increased, grain yield, spike m^{-2} , and number of grains per spike.

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