The Comparative Study of Yield and Yield Component Traits of Four Cereal Crops under Rainfed Conditions Affected by Different Seed Rates

Mohammad Tofiq Mohammad[1*], Banaz Ahmed Hama Ameen[2]

[1] College of Agricultural Sciences. University of Sulaimani, Sulaimani, Iraq

[2] Halabja Agriculture Technical College. Sulaimani Polytechnic University, Sulaimani, Iraq

*Corresponding author (Email: mohammad.mohammad@univsul.edu.iq)

Abstract

The present investigation was conducted during the winter season of 2011– 2012, at two different locations Qlyasan Agricultural Research Station and Research field at Penjwen, to comparison yield and yield component traits of four cereal crops under different seed rates with their interactions. The four cereal crops were durum wheat, barley, triticale, and rye, while the four different seed rates were 120, 160, 200 and 240 kg ha^{-1}, using split plot design in which main plots in RCBD within four replicates. The four cereal crops were implemented in the main plots while the different seed rates were implemented in the sub-plots. Statistical analysis showed the presence of highly significant differences among the four cereal crops for all studied traits at both locations and their average except carbohydrate content. The results showed that triticale exceeded other crops in grain yield, biological yield and harvest index at both locations and their average. Wheat crop produced maximum values of average spike weight, grain weight spike^{-1}, number of grains spikelet^{-1} and 1000 grain weight at both locations and their average. The lowest values of grain yield and biological yield were recorded under lowest seed rate 120 kg ha^{-1} at both locations and their average. It was noticed that increasing seed rates caused increases in grain yield and biological yield step by step. The seed rate 160 kg ha^{-1}recorded maximum values for the traits spike length, spike weight plant^{-1}, grain weight plant^{-1} and the number of grains spike^{-1}, while the seed rate 200 kg ha^{-1}produced the highest values for both traits grain weight spike^{-1} and 1000 grain weight.

Statistical results showed that the effect of interaction between cereal crops and seed rates were not significant on yield traits and chemical components at both locations and their average except grain yield and carbohydrate content of Qlyasan location. Due to yield component and related traits, the results showed that the effect of interactions was significant or highly significant on some of the traits. Qlyasan location predominated Penjwen location in all of the traits except harvest index.

Keywords: Cereals; durum wheat; barley; triticale; rye; yield and yield component traits; chemical traits; seeding rates

Introduction

Cereals are important staple foods for mankind worldwide and represent the main constituent of animal feed (Peter and Herbert, 2012). Cereals are defined as flowering plants of the grass family (Poaceae), cultivated primarily for their starchy seeds, for human food and livestock feed, as well as for other uses. The cereal name derives from Ceres, the Roman goddess of grain (Wrigley *et al.,* 2004). Cereals are members of the grass family; they are the most important cultivated crops and considered the greatest source of energy and protein for human and domesticated animal diets (Rajaram, 1995).

Seeding rates for cereals (such as wheat and barley) has a direct influence on the number of spikes m^{-2} and grain yield, on the other hand, maximum cereal yields may be achieved over a wide range of seeding rates due to compensation of yield components "tillers plant^{-1}, number of kernels spike^{-1}, kernel size" (Tompkins *et al.*, 1991). Grain yield in cereal is defined by the number of grains per unit area and by the individual weight of these grains; in general, grain yield is closely the number of grains per spike and per spikelet (Sayre *et al.*, 1997). The quality of grain is a complex of physical and chemical characters whose expression depends on their genotypic "genetic nature" and influence of the environment (Johansson, 2002). The actual yield of cereals has come from the value of yield components, factors of environmental as well as agricultural practices, levels of water, fertilizer, pesticide application; all together play important role in cereal yield increasing (Jolánkal *et al.*, 2006).

Wheat *Triticum* spp. is one of the most important cereal crops in the world. It is grown across a wide range of environments around the world and has the highest adaptation among all the crop species. It is the main staple food of nearly 35 percent of the world population than any other food source (Singh, 1988). Durum wheat is one of the most important food crops in different countries; it is a major crop in the Mediterranean basin of west Asia, North Africa, and Southern Europe (Elias and Manthey, 2005).. Wheat is the stable diet for more than one third of the world population and contributes more calories and protein to the world diet than any other cereal crop (Abd-El-Haleem *et al.*, 2009).

Barley *Hordeum vulgare* L. is one of the world’s oldest crop plants. While its origins are unknown, humans may have consumed it as early as 15,000 B. C. It belongs to the family (Poaceae) and is grown primarily for malting grain and as livestock feed (Akar *et al.,* 2004). A small amount of barley is used for food, and cultivated barley is mainly grown for animal feed, for malting and brewing in the manufacture of beer and distilling in whiskey manufacture (FAOSTAT, 2012). According to Darvey *et al.,* (2000), worldwide yields averaged 2.97 ton ha^{-1} in 2017.

Triticale is the first cereal produced by man through crossing wheat *Triticum* spp. and rye *Secale cereal* L., the future of this crop is bright because it is environmentally more flexible than other cereals and shows better tolerance to diseases, drought, and pests than its parental species (Darvey *et al.,* 2000). It is, however, not susceptible to diseases which attack wheat and rye (Macrae *et al.,* 1993). Triticale is used mainly as a feed crop but it can be milled into flour and used to make bread, although adjustments are needed in recipe formulation because it does not have the same gluten content as wheat (Kent and Evers, 1994). Triticale has superior nutritional qualities over wheat and baking qualities over rye (Ammar *et al.,* 2004). Global production in 2017 was estimated at 16.95 million metric tons (FAOSTAT, 2017).

Rye is the common name for members of the genus *Secale* of the grass family and the cereal grains produced by those grasses. Rye *Secale cereale* L. is a grass plant of the family (Poaceae), cultivated worldwide and used as grain and straw. It is also important in the production of mixed feeds for livestock. Straw is used in livestock feeds, as bedding in animal husbandry, and as a building material (Bushuk, 2004). Rye is nowadays the second most used grain for bread making, and it is likely to gain interest and popularity (Bushuk, 2001). According to (FAOSTAT, 2017), the production of this cereal is approximately 12.73 million tons in the world, and this accounts for almost 92% of its production in Europe.

The aims of the present study were to assess and comparison some yield and yield component traits in wheat, barley, triticale and rye at Qlyasan and Penjwen, which belong to two different agro-climatic conditions.

Materials and Methods

This investigation was conducted at two different locations, Qlyasan research station (Lat 35˚ 34΄ 30˝ N; Long 45˚ 21΄ 43˝ E, 765 m above sea level) located 2 km North West of Sulaimani and research field at Penjwen (Lat 35˚ 37΄ 20˝ N; Long 45˚ 56΄ 38˝ E, 1302 m above sea level), during the winter season of 2011 - 2012. The differences were based on soil characteristics, rainfall distribution, temperature means, plant type, cropping pattern and other ecological characteristics.

Four cereal crop cultivars (durum wheat "SEMETO", six-row barley "DURRA", triticale "CLOSSBID" and common rye "PARSHA") were used in this study to evaluate and comparison yield and yield component traits of the four cereals under four different seed rates (120, 160, 200 and 240kg ha^{-1}), with their interactions. The two field experiments were laid out according to Split Plot Design within four replicates. The four cereal crops (wheat, barley, triticale and rye) were implemented in the main plots which arranged with RCBD, while the different seed rates (120, 160, 200, 240kg ha^{-1}) were implemented in the sub-plots. Each replicate consisted of four main plots with the distance of 1m between replicates, and each main plot contained four sub plots with three rows of 4 m long, the distance between rows were 0.25 m (Al- Mohamad and Yonis, 2000). The lands of the experiments at both locations were prepared by plowing the field twice. Seeds were drilled on (Dec. 1 and Dec. 3) of 2011 at Qlyasan and Penjwen locations respectively. All cultural practices were conducted whenever were necessary. All treatments were harvested carefully at maturity time. The studied traits included, yield traits: grain yield (ton ha^{-1}), biological yield (ton ha^{-1}), harvest index and yield component and related traits: spike length (cm), average spike weight (g), spike weight plant^{-1} (g), grain weight plant^{-1} (g), number of grains spike^{-1}, grain weight spike^{-1} (g), number of spikelet spike^{-1}, number of grain spikelet^{-1}, 1000 grain weight (g) and chemical traits: protein content %, ash content %, and carbohydrate content %.

Appendix 1 shows Agro-meteorological data of both locations Qlyasan and Penjwen during the season of (2011-2012).

Statistical Analysis: The experiments were conducted according to Split Plot Design within four replications; all data were statistically analyzed at 5% significant level for both locations according to the methods of analysis of variance (ANOVA), combined analysis of variance for the average of both locations was conducted. Least significant differences (LSD) at 5% significant level were used to compare between mean traits.

Results and Discussion

A. Effect of cereal crop cultivars on yield traits:

1. Grain yield

Data in Table 1 demonstrated highly significant differences among crops for the trait grain yield at both locations and their average, the results showed that triticale exceeded other crops in grain yield recording 1.372, 1.226 and 1.229 ton ha^{-1} for both locations and their average respectively, followed by 1.212, 0.916 and 1.064 ton ha^{-1} recorded by wheat at both locations and their average respectively. Regarding the same table, it was noticed that the minimum values of grain yield were 0.808, 0.748 and 0.778 ton ha^{-1} produced by the rye crop at both locations and their average respectively. It was noticed that the performance of cereal crops differed from Qlyasan to Penjwen location, this may be due to the differences in climatic conditions. Differences in grain yield among cereal crops were recorded by previous researchers, (Jaczewska, 2008) showed that the variability in grain yield from year to another is a result of many factors co-operating each with other throughout the whole vegetation period.

2. Biological yield

Table 1 showed that there were highly significant differences among the cereal crops due to biological yield at both locations and their average. The results showed that the maximum values of biological yield were 7.485, 5.793 and 6.639 ton ha^{-1} exhibited by triticale at both locations and their average respectively, followed by 7.071, 4.544 and 5.743 ton ha^{-1} recorded by barley, wheat and also barley for both locations and their average respectively. Concerning the same table, it was found that the minimum values of biological yield were 4.958, 4.030 and 4.494 ton ha^{-1} showed by the rye at both locations and their average respectively. The differences of biological yield between the two locations Qlyasan and Penjwen may refer to the different environments of the locations similar results were reported previously by Donaldson et al. (2001).

3. Harvest index

Data represented in Table 1 confirmed highly significant differences among crops due to the trait harvest index at Qlyasan and the average of both locations, while it was not significant at Penjwen location. The same table showed that the maximum values of harvest index were 0.189, 0.216 and 0.203 exhibited by triticale for both locations and their average respectively. Similar results were detected by Hamid et al. (2005). Concerning the same table, it was noticed that triticale revealed the maximum values of all yield traits at both locations, while the crop rye showed the minimum values of grain yield and biological yield at both locations. As mentioned before, there were significant differences due to crop responses to the different environmental factors at the two locations.

Table 1: Effect of cereal crop cultivars on yield traits at both locations and their average.

Crops	Grain yield (ton ha^{-1})	Biological yield (ton ha^{-1})	Harvest index (%)
Qlyasan location			
Wheat	1.212	6.616	18.800
Barley	1.089	7.071	15.800
Triticale	1.372	7.485	18.900
Rye	0.808	4.958	16.600
$LSD_{(0.05)}$	0.075**	0.807**	2.1**
Penjwen location			
Wheat	0.916	4.544	20.500
Barley	0.827	4.414	18.800
Triticale	1.226	5.793	21.600
Rye	0.748	4.030	19.600
$LSD_{(0.05)}$	0.102**	0.427**	N.S
Average of both locations			
Wheat	1.064	5.580	19.600
Barley	0.958	5.743	17.300
Triticale	1.299	6.639	20.300
Rye	0.778	4.494	18.100
$LSD_{(0.05)}$	0.059**	0.424**	1.4**
N.S: Non Significant *: Significant **: Highly Significant			

B. Effect of cereal crop cultivars on yield component and related traits:

1. Spike length

Data in Table 2 indicated highly significant differences among cereal crops for the trait spike length at both locations and their average. The results showed that maximum spike length at Qlyasan location was 12.49 cm exhibited by triticale, followed by 6.58 cm for wheat crop and the minimum value of spike length was 5.56 cm produced by barley. The same table revealed that the maximum value of spike length at Penjwen location was 10.23cm also produced by triticale, followed by 6.25cm showed by barley, whereas the minimum spike length was 5.13 cm produced by wheat. The results showed that the maximum spike length at the average of both locations was 11.36 cm produced by triticale and the minimum spike length was 5.86 cm recorded by the wheat. Similar resulted obtained previously by (Mohammad *et al*., 2011).

2. Average spike weight

Data present in Table 2 showed highly significant differences among crops in average spike weight at both locations and their average. It was showed that the wheat crop produced maximum values of average spike weight with 3.47, 2.84 and 3.16 gm at both locations and their average respectively, followed by 3.11, 2.73 and 2.92 gm recorded by triticale at both locations and their average respectively. Regarding the same table, the minimum values of average spike weight were 0.92, 0.80 and 0.86 gm produced by cereal crop rye at both locations and their average respectively. Previous studies recorded different values of average spike weight. Meerza (2012) showed that the maximum value of average spike weight produced by triticale.

3. Spike weight plant^{-1} (g) and grain weight plant^{-1}

Data represented in Table 2 showed highly significant differences among crops for both traits spike weight plant^{-1} and grain weight plant^{-1} at both locations and their average. Results in Table (2), indicated that the wheat crop at Qlyasan exceeded all other crops recording (8.98 g and 6.66 g) for spike weight plant^{-1}and grain weight plant^{-1} respectively, followed by (5.59 g and 4.21 g) recorded by triticale for both traits respectively, while the minimum value for the spike weight plant^{-1} and grain weight plant^{-1} were (2.58 g and1.83 g) detected by rye crop respectively. Data in the same table for Penjwen location showed that the wheat crop also exceeded other crops recording (5.83 and 4.18 g) for spike weight plant^{-1}and grain weight plant^{-1} respectively, followed by (4.89 and 3.44

g) exhibited by triticale for spike weight plant^{-1}and grain weight plant^{-1}respectively, whereas the minimum values of the spike weight plant^{-1}and grain weight plant^{-1} were (2.23 and1.51 g) observed by rye crop respectively. Regarding the same table, data for the average of both locations detected that the maximum values of spike weight plant^{-1}and grain weight plant^{-1} were (7.41 and 5.42 g) observed by wheat crop, while the minimum values for both traits were (2.40 and1.67 g) produced by the cereal rye respectively. In a genetic study (Meerza, 2012) reported that there were no significant differences among genotypes for spike weight plant^{-1} and grain weight plant^{-1}.

4. Number of grains spike^{-1}

Table 2 indicated the presence of highly significant differences among crops for trait number of grains spike^{-1} at both locations and their average. Results showed that triticale exceeded all other crops in number of grains spike^{-1} with 55.48, 50.93 and 53.20 grains at both locations and their average respectively, followed by 52.28, 43.91 and 48.09 grains recorded by the wheat crop for both locations and their average respectively. Regarding the same table, it was noticed that the minimum number of grains spike^{-1} were 24.45, 22.94 and 23.69 grains,

---

Table 2: Effect of cereal crops on yield component and related traits at both locations and their average.

Crops	Spike length (cm)	Average spike weight (g)	Spike weight plant^{-1} (g)	Grain weight plant^{-1} (g)	No. of grains spike^{-1}	Grain weight spike^{-1} (g)	No. of spikelet spike^{-1}	No. of grains spikelet^{-1}	1000 Grain weight (g)
Qlyasan location									
Wheat	6.58	3.47	8.98	6.66	52.28	2.81	18.89	3.36	51.86
Barley	5.56	1.29	3.24	2.80	36.83	1.21	48.41	1.00	31.88
Triticale	12.49	3.11	5.59	4.21	55.48	2.20	28.16	2.43	39.50
Rye	6.43	0.92	2.58	1.83	24.45	0.83	19.27	1.74	34.33
$LSD_{(0.05)}$	0.84**	0.23**	1.53**	0.69**	4.61**	0.22**	3.43**	0.24**	2.93**
Penjwen location									
Wheat	5.13	2.84	5.83	4.18	43.91	2.11	16.01	3.16	47.30
Barley	6.25	1.49	3.56	2.71	35.13	1.24	56.38	1.00	34.49
Triticale	10.23	2.73	4.89	3.44	50.93	1.83	24.56	2.56	34.50
Rye	5.32	0.80	2.23	1.51	22.94	0.71	17.31	1.74	30.33
$LSD_{(0.05)}$	0.54**	0.46**	0.41**	0.33**	2.47**	0.15**	1.07**	0.16**	1.74**
Average of both locations									
Wheat	5.86	3.16	7.41	5.42	48.09	2.46	17.45	3.26	49.58
Barley	5.91	1.39	3.40	2.75	35.98	1.23	52.39	1.00	33.19
Triticale	11.36	2.92	5.24	3.83	53.20	2.01	26.36	2.49	37.00
Rye	5.88	0.86	2.40	1.67	23.69	0.77	18.29	1.74	32.33
$LSD_{(0.05)}$	0.47**	0.24**	0.47**	0.35**	2.43**	0.12**	1.67**	0.14**	1.58**

N.S: Non Significant *: Significant **: Highly Significant

produced by the rye crop at both locations and their average It was noticed that the performance of cereal crop cultivated was differed especially in number of grains spike^{-1} at two locations, this may be due to the differences in climatic conditions. Differences among crop cultivated were investigated by previous researchers (Hussain *et al*., 2001 and Ramazan *et al*., 2009).

5. Grain weight spike^{-1}

Data showed in Table 2 represented highly significant differences among cereal crops for the trait grain weight spike^{-1} at both locations and their average. The results indicated that wheat crop exceeded all other crops in grain weight spike^{-1} recording 2.81, 2.11 and 2.46 g for both locations and their average respectively, followed by 2.20, 1.83 and 2.01 g recorded by triticale at both locations and their average respectively. Table (2), also showed that the minimum values of grain weight spike^{-1} were 0.83, 0.71 and 0.77 g exhibited by the rye crop at both locations and their average respectively. The previous study revealed that the grain weight spike^{-1} was also variable depending on cultivated crops. Ramazan *et al*. (2009) revealed that the differences among genotypes were significant for grain weight spike^{-1}.

6. Number of spikelets spike^{-1}

Data represented in Table 2 showed that there were highly significant differences among cultivated crops in number of spikelets spike^{-1} at both locations and their average. Data in Table (2) indicated that the barley produced the highest number of spikelets spike^{-1} with 48.41, 56.38 and 52.39 for both location and their average respectively, followed by 28.16, 24.56 and 26.36 recorded by triticale for both locations and their average respectively. Results in the same table showed that the lowest number of spikelets spike^{-1} was 18.89, 16.01 and 17.45 accumulated by wheat crop at both locations and their average respectively. The differences among crops due to number of spikelets spike^{-1} may be return to the genetic composition of the crops. Similar results were reported by Meerza (2012) and Ahmad (2010).

7. Number of grains spikelet^{-1}

Data in Table 2 revealed the presence of highly significant differences among all cereal crops in number of grains spikelet^{-1} at both locations and their average. The results present in the same table detected that the wheat crop exceeded all other crops in number of grains spikelet^{-1} recording 3.36, 3.16 and 3.26 grains for both locations and their average respectively, followed by 2.43, 2.56 and 2.49 produced by triticale at both locations and their average respectively. Whereas the lowest numbers of grains spikelet^{-1} accumulated by barley with 1.00 grain spikelet^{-1} at both location and their average. The previous study by Meerza (2012) obtained highly significant differences among genotypes for the trait number of grains spikelet^{-1}.

8. 1000 grain weight

Data in Table 2 detected highly significant differences among crops for trait 1000 grain weight at both locations and their average. Results revealed that the maximum values of this trait were 51.86, 47.30 and 49.58 g exhibited by wheat crop for both locations and their average respectively, followed by 39.50, 34.50 and 37.00 g recorded by triticale at both locations and their average respectively. Regarding the same table, it was showed that the minimum values of 1000 grain weight were 31.88g exhibited by the barley at Qlyasan location, whereas the minimum values of this trait at Penjwen and the average of both locations were 30.33 and 32.33 g showed by the rye crop respectively. Similar results were reported by Mohammed (2012) who showed highly significant differences among genotypes and observed that Semeto genotype showed maximum values of 1000 grain weight with (35.90 g). The results of crop performances showed that wheat crop recorded the highest values of average spike weight, spike weight plant^{-1}, grain weight plant^{-1}, grain weight spike^{-1}, number of grains spikelet^{-1} and 1000 grain weight at both locations and their average, while triticale showed the highest values of spike length and number of grains spike^{-1} at both locations and their average, whereas the rye crop among all crops revealed the lowest values of traits (average spike weight, spike weight plant^{-1}, grain weight plant^{-1}, number of grains spike^{-1}, grain weight spike^{-1}) at both locations and their average. As it was noticed, the genotype of crop cultivars and environmental factors may affect significantly on yield and all yield component traits. Previous studies were proved this fact Gibson *et al*., 1999 and Royo *et al*., 2000)

C. Effect of seed rates on yield traits:

1. Grain yield

Data in Table 3 confirmed highly significant differences on grain yield due to the effects of seed rates. The results revealed that the lowest values of grain yield were 0.93, 0.76 and 0.84 ton ha^{-1} recorded under lowest seed rate 120 kgha^{-1} at both locations and their average respectively. It was noticed that increasing seed rates caused increases in grain yield step by step, which observed that increasing seed rates from (120 to 200 kg ha^{-1} and to 240 kg ha^{-1}) caused an increase in grain yield from (0.93 to 1.18 and to 1.26 ton ha^{-1}) at Qlyasan location and from (0.76 to 1.02 and to 1.04 ton ha^{-1}) at Penjwen location, while at the average of both locations it was increased from (0.84 to 1.10 and 1.15 ton ha^{-1}) respectively. Previous research results confirmed that maximum cereal yields might be achieved over a wide range of seeding rates due to compensation of yield components (Tompkins *et al.,* 1991).

2. Biological yield

Data present in Table 3 showed highly significant differences due to the effects of seed rates on biological yield at both locations and their average. Data in the same table revealed that the lowest values of biological yield produced under lowest seed rate 120 kg ha^{-1} which was (4.85, 3.42 and 4.13 ton ha^{-1}) for both locations and their average respectively. It was observed that increasing seed rates from (120 kg ha^{-1} to 200 kg ha^{-1} and to 240 kg ha^{-1}) caused an increase in biological yield from (4.85 to 7.75ton ha^{-1}) at Qlyasan location and from (3.42 to 5.73 ton ha^{-1}) and from (4.13 to 6.74 ton ha^{-1}) at Penjwen and the average of both locations respectively. Previous studies were proved this fact (Donaldson *et al*., 2001). As it was present in Table (3) an increasing in both grain yield and biological yield by increasing seed rates at both locations may resulted from increasing total number of plants per unit area which reflected in increasing total grain yield and biological yield.

3. Harvest index

Data in (Table 3) showed highly significant differences due to the effect of seed rates on harvest index at both locations and their average. The results in Table (3), indicated that the maximum values of harvest index were (0.196, 0.223 and 0.209) recorded under the lowest seed rate 120 kg ha^{-1} for both locations and their average respectively. Data in the same table showed that increasing in seed rates from 120 kg ha^{-1} to 240 kg ha^{-1} caused decreasing in harvest index from (0.196 to 0.162), (0.223 to 0.185) and (0.209 to 0.173) at both locations and their average respectively. Differences in harvest index were observed previously by Hamid *et al*. (2005).

D. Effect of seed rates on yield component and related traits

Table 4 showed no significant effect of seed rates on all yield component traits at Qlyasan location with the exception of spike length and 1000 grain weight which were significant. It was noticed that low seed rates produced maximum spike length which was (8.01 and 8.10 cm) for seed rate 120 and160 kg ha^{-1} respectively, while the lowest value of spike length recorded under seed rate 240 kg ha^{-1} with 7.43 cm. And it was found that the maximum value of 1000 grain weight at Qlyasan location was (40.78 g) recorded under seed rate 200 kg ha^{-1}, whereas the minimum value was (38.54 g) observed under the lowest seed rate 120kg ha^{-1}.

Table 3: Effect of seed rates on yield traits at both locations and their average.

Seed rates	Grain yield (ton ha^{-1})	Biological yield (ton ha^{-1})	Harvest index
Qlyasan location			
120 kg ha^{-1}	0.93	4.85	0.196
160 kg ha^{-1}	1.11	6.35	0.179
200 kg ha^{-1}	1.18	7.18	0.164
240 kg ha^{-1}	1.26	7.75	0.162
$LSD_{(0.05)}$	0.06**	0.52**	0.016**
Penjwen location			
120 kg ha^{-1}	0.76	3.42	0.223
160 kg ha^{-1}	0.90	4.42	0.205
200 kg ha^{-1}	1.02	5.21	0.192
240 kg ha^{-1}	1.04	5.73	0.185
$LSD_{(0.05)}$	0.08**	0.44**	0.020**
Average of both locations			
120 kg ha^{-1}	0.84	4.13	0.209
160 kg ha^{-1}	1.01	5.39	0.192
200 kg ha^{-1}	1.10	6.20	0.178
240 kg ha^{-1}	1.15	6.74	0.173
$LSD_{(0.05)}$	0.05**	0.33**	0.013**
N.S: Non Significant *: Significant **: Highly Significant			

Table 4 indicated highly significant differences due to the effect of seed rates at Penjwen location on some yield component traits which were "average spike weight, spike weight plant^{-1}, grain weight plant^{-1}, number of grains spike^{-1} and grain weight spike^{-1}" while the other yield component traits were not significant. Results in the same table detected that the maximum values of those traits at Penjwen location recorded under seed rate 160kg ha^{-1} with (2.22, 4.67, 3.36, 41.39 and 1.64) for traits "average spike weight, spike weight plant^{-1}, grain weight plant^{-1}, number of grains spike^{-1} and grain weight spike^{-1}" respectively. Regarding the same table for Penjwen location, it was noticed that the lowest values recorded under the lowest seed rates 120 kg ha^{-1} were 3.63 and 2.61g for both traits spike weight plant^{-1} and grain weight plant^{-1} respectively. On the other hand, it was shown that the increasing in seed rates from (160 to 200 kg ha^{-1}) caused decreasing in average spike weight from (2.22 to1.86 g), and increasing in seed rates from (160 to 240 kg ha^{-1}) caused decreasing from (41.39 to 35.77) and (1.64 to1.36 g) for both traits number of grains spike^{-1} and grain weight spike^{-1} respectively. Data in Table 4 indicated highly significant differences due to the effect of seed rates on spike weight plant^{-1}, number of grains spike^{-1}, grain weight spike^{-1} respectively. Data in Table 4 indicated highly significant differences due to the effect of seed rates on spike weight plant^{-1}, number of grains spike^{-1}, grain weight spike^{-1} and significant effect on spike length, grain weight plant^{-1} and 1000 grain weight, whereas it was not significant on other yield component traits at the average of both locations. Data in the same table revealed that the seed rate 160 kg ha^{-1} recorded maximum values with (7.43 cm, 4.95g, 3.65g, and 41.91) for the traits spike length, spike weight plant^{-1}, grain weight plant^{-1} and number of grains spike^{-1} respectively, while the seed rate 200 kg ha^{-1} produced the highest values with (1.71 and 38.83 g) for both traits grain weight spike^{-1} and 1000 grain weight respectively. Results were also observed that the higher grain number obtained in the lowest seed rate(Hussain *et al.,* 2001). Regarding the average of both locations in the same table, it was observed that the lowest seed rate 120 kg ha^{-1} recorded the lowest values with (4.29, 3.17 and 37.10 g) for traits spike weight plant^{-1}, grain weight plant^{-1} and 1000 grain weight respectively, while the highest seed rate 240kg ha^{-1} showed the lowest values with (7.05 cm, 38.48 and 1.50 g) for the traits spike length, number of grains spike^{-1} and grain weight spike^{-1}. Similar results showed previously by Korres and Williams (2002) and Madan and Munjal (2009).

E. Effect of interaction between cereal crops and seed rates on yield traits:

Table 5 represents the effect of interactions between crops and seed rates on yield traits at both locations and their average, and it was shown that the effect was not significant on yield traits at both locations and their average except grain yield at Qlyasan which was significant. Data in the same table revealed that the maximum value of grain yield at Qlyasan

Table 4: Effect of seed rates on yield component and related traits at both locations and their average.

Seed rates	Spike length (cm)	Average spike weight (g)	Spike weight plant^{-1} (g)	Grain weight plant^{-1} (g)	No. of grains spike^{-1}	Grain weight spike^{-1} (g)	No. of spikelet spike^{-1}	No. of grains spikelet^{-1}	1000 Grain weight (g)
Qlyasan location									
120 kg ha^{-1}	8.01	2.20	4.94	3.73	42.03	1.76	28.49	2.11	38.54
160 kg ha^{-1}	8.10	2.17	5.23	3.93	42.43	1.76	28.60	2.24	39.56
200 kg ha^{-1}	7.52	2.27	5.43	4.20	43.39	1.89	29.00	2.13	40.78
240 kg ha^{-1}	7.43	2.16	4.79	3.63	41.19	1.64	28.64	2.05	38.69
$LSD_{(0.05)}$	0.52*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	1.54*
Penjwen location									
120 kg ha^{-1}	6.78	1.91	3.63	2.61	36.21	1.38	28.89	2.15	35.66
160 kg ha^{-1}	6.76	2.22	4.67	3.36	41.39	1.64	28.42	2.12	37.26
200 kg ha^{-1}	6.74	1.86	4.21	2.98	39.53	1.52	29.31	2.03	36.87
240 kg ha^{-1}	6.66	1.89	4.01	2.89	35.77	1.36	27.65	2.17	36.84
$LSD_{(0.05)}$	N.S	0.22**	0.50**	0.05**	3.61**	0.17**	N.S	N.S	N.S
Average of both locations									
120 kg ha^{-1}	7.39	2.05	4.29	3.17	39.12	1.57	28.68	2.13	37.10
160 kg ha^{-1}	7.43	2.20	4.95	3.65	41.91	1.70	28.51	2.18	38.41
200 kg ha^{-1}	7.13	2.06	4.82	3.59	41.46	1.71	29.16	2.08	38.83
240 kg ha^{-1}	7.05	2.02	4.40	3.26	38.48	1.50	28.15	2.11	37.77
$LSD_{(0.05)}$	0.32*	N.S	0.44**	0.33*	2.36**	0.12**	N.S	N.S	1.08*

N.S: Non Significant *: Significant **: Highly Significant location was 1.58 ton ha^{-1} exhibited by triticale as interact with seed rate 240 kg ha^{-1}, followed by 1.51 ton ha^{-1} also for triticale with seed rate 200 kg ha^{-1} followed by 1.37 ton ha^{-1} produced by wheat as interact with seed rate 240 kg ha^{-1}, while the minimum value was 0.71 ton ha^{-1} detected by rye crop as interacting with seed rate 120 kg ha^{-1}. Regarding the same table, it was noticed that increasing the seed rates from 120 kg ha^{-1} to 240 kg ha^{-1} caused increasing grain yield for the cereal crops (from 0.97 to 1.37, from 0.91 to 1.18, from 1.14 to 1.58 and from 0.71 to 0.92) ton ha^{-1} for wheat, barley, triticale and rye respectively. Different results were showed previously by Rafique *et al*. (2010).

F. Effect of locations on yield traits

Data in (Table 6) indicated highly significant differences due to the effect of locations on yield traits (grain yield, biological yield and harvest index). The results in the same table clarified that Qlyasan location out yielded Penjwen location by (20.34 and 38.94 %) for both traits grain yield and biological yield respectively. This may be due to the suitability of environmental factors at Qlyasan location such as temperature, humidity, and distribution of precipitation. For harvest index trait it was revealed that Penjwen location predominated Qlyasan location by 11.11% in harvest index. Previous researchers showed differences in yield and yield component traits (Alam *et al.*, 2007).

G. Effect of locations on yield component and related traits

As shown in (Table 7) there were highly significant differences due to the effect of locations on spike length, spike weight plant^{-1}, grain weight plant^{-1}, number of grains spike^{-1} and grain weight spike^{-1}, while there was significant effect of locations on average spike weight and 1000 grain weight. The results in the same table showed that Qlyasan location predominated Penjwen location in all yield component traits by (15.45, 11.68, 23.49, 30.74, 10.57, 19.73 and 7.45 %) for traits spike length, average spike weight, spike weight plant^{-1}, grain weight plant^{-1}, number of grains spike^{-1}, grain weight spike^{-1} and 1000 grain weight respectively. The previous study showed the effect of locations on yield component characters (Ahmad, 2010).

Table 5: Effect of interaction between cereal crops and seed rates on yield traits at both locations and their average.

Crops	seed rates	Qlyasan location			Penjwen location			Average of both locations		
		Grain yield ton ha^{-1}	Bio. yield ton ha^{-1}	Harvest index	Grain yield ton ha^{-1}	Bio. yield ton ha^{-1}	Harvest index	Grain yield ton ha^{-1}	Bio. yield ton ha^{-1}	Harvest index
Wheat	$120kgha^{-1}$	0.97	4.53	0.22	0.76	3.64	0.21	0.86	4.08	0.21
	$160kgha^{-1}$	1.27	6.70	0.19	0.88	4.04	0.22	1.08	5.37	0.21
	$200kgha^{-1}$	1.25	6.96	0.18	1.03	5.19	0.20	1.14	6.07	0.19
	$240kgha^{-1}$	1.37	8.28	0.17	1.00	5.32	0.19	1.19	6.80	0.18
Barley	$120kgha^{-1}$	0.91	5.23	0.18	0.68	3.57	0.19	0.79	4.40	0.19
	$160kgha^{-1}$	1.14	7.43	0.16	0.77	3.83	0.21	0.95	5.63	0.18
	$200kgha^{-1}$	1.13	7.65	0.15	0.89	4.94	0.17	1.01	6.29	0.16
	$240kgha^{-1}$	1.18	7.98	0.15	0.98	5.33	0.19	1.08	6.66	0.17
Triticale	$120kgha^{-1}$	1.14	5.98	0.19	0.98	3.76	0.26	1.06	4.87	0.23
	$160kgha^{-1}$	1.26	6.46	0.21	1.24	6.10	0.20	1.25	6.28	0.21
	$200kgha^{-1}$	1.51	8.79	0.17	1.38	6.47	0.21	1.44	7.63	0.19
	$240kgha^{-1}$	1.58	8.72	0.19	1.31	6.84	0.19	1.45	7.78	0.19
Rye	$120kgha^{-1}$	0.71	3.64	0.20	0.62	2.73	0.23	0.66	3.18	0.21
	$160kgha^{-1}$	0.78	4.81	0.16	0.71	3.73	0.23	0.75	4.27	0.18
	$200kgha^{-1}$	0.82	5.35	0.16	0.79	4.23	0.19	0.80	4.79	0.17
	$240kgha^{-1}$	0.92	6.04	0.15	0.88	5.43	0.18	0.90	5.74	0.16
$LSD_{(0.05)}$		0.13*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

N.S: Non Significant *: Significant **: Highly Significant

Table 6: Effect of locations on yield traits.

Location	Grain yield (ton ha^{-1})	Biological yield (ton ha^{-1})	Harvest index
Qlyasan	1.12	6.53	0.18
Penjwen	0.93	4.70	0.20
$LSD_{(0.05)}$	0.10^{**}	0.30^{**}	0.01^{**}
N.S: Non Significant *: Significant **: Highly Significant			

Table 7: Effect of locations on yield component and related traits.

Location	Spike length (cm)	Average spike weight (g)	Spike weight $plant^{-1}$ (g)	Grain weight $plant^{-1}$ (g)	No. of grains $spike^{-1}$	Grain weight $spike^{-1}$ (g)	No. of spikelet $spike^{-1}$	No. of grains $spikelet^{-1}$	1000 Grain weight (g)
Qlyasan	7.77	2.20	5.10	3.87	42.26	1.76	28.68	2.13	39.39
Penjwen	6.73	1.97	4.13	2.96	38.22	1.47	28.56	2.12	36.66
$LSD_{(0.05)}$	0.32^{**}	0.22^{*}	0.34^{**}	0.26^{**}	1.67^{**}	0.18^{**}	N.S	N.S	2.35^{*}
N.S: Non Significant *: Significant **: Highly Significant									

Conclusions

- Analysis of variance detected that highly significant differences revealed between the cereal crop cultivars for all traits at both locations and their average except harvest index in Penjwen location.
- Wheat crop exceeded others in most of the yield component traits such as average spike weight, spike weight plant^{-1}, grain weight plant^{-1}, grain weight spike^{-1}, number of grains spikelet^{-1} and 1000 grain weight, while it was possessed the lowest values in a number of spikelet spike^{-1} at both locations and their average.
- The barley crop exhibited others in a number of spikelet spike^{-1} whereas it was produced the lowest values in harvest index and the number of grains spikelet^{-1} at both locations and their average.
- Triticale exceeded the rest in traits grain yield, biological yield, harvest index, spike length and number of grains spike^{-1} at both locations and their average.
- Cereal rye cultivar showed the lowest values in grain yield, biological yield and most of the yield component traits such as average spike weight, spike weight plant^{-1}, grain weight plant^{-1}, number of grains spike^{-1} and grain weight spike^{-1} at both locations and their average.
- The seed rate of 240 kg ha^{-1} exhibited the highest values for grain yield and biological yield, while the seed rate of 120 kg ha^{-1} showed the highest value of harvest index at both locations and their average.
- The seed rates had no effects on both trait numbers of spikelet spike^{-1} and the number of grains spikelet^{-1} at both locations and their average.
- The out yielding of most studied traits, including yield and yield component traits at Qlyasan location compared to Penjwen location, may be resulted in the suitability of environmental factors at Qlyasan including the amount of precipitation during the growing stages and the temperature effect through anthesis and grain filling period.
- The locations had no effects on both traits number of spikelet spike^{-1}, number of grains spikelet^{-1}.

Recommendations:

- Conducting further working on cereal crop cultivars at different environmental conditions, and survival at the climatically conditions prevailing in Kurdistan region.
- Further studies could be required to evaluate further varieties of triticale and wheat which possess higher yield with good quality and survival potentials to the climatically conditions prevailing in Kurdistan region

- Triticale exceeded the rest in grain yield, biological yield, harvest index and other traits. Therefore we recommend triticale to be cultivated at both locations Qlyasan and Penjwen, and this may support animal feed and human consumption especially under unfavorable conditions.
- Using 200kg ha^{-1} seed rate recorded the highest values for grain yield and biological yield; therefore, we recommend this amount to be used at both locations Qlyasan and Penjwen.

References

Abd-El-Haleem, S. H. M., M. A. Reham and S. M. S. Mohamed (2009). Genetic analysis and RAPD polymorphism in some durum wheat genotypes. *Global J. of Biotech .and Bio.*, 4, 1-9.

Ahmad, M. M. (2010). Triticale as an alternative crop to wheat and barley under different Sulaimani conditions. *MSc. in Field Crop, Cereal Production.* College of Agr. Sulaimani Univ.

Akar, T., M. Avaci, and F. Dusunceli (2004). BARLEY: Post-Harvest Operations, Edited by AGST/FAO: Danilo Mejía, PhD, FAO (Technical), Last reviewed: (15/06/2004), Cited from internet: http://www.ibrarian.net/navon/page.jsp?paperid=18590397.

Alam, M. Z., S. A. Haider and N. K. Paul (2007). Yield and Yield Components of Barley cultivars in Relation to Nitrogen Fertilizer of Applied Sciences Research, 3(10): 1022-1026.

Ammar, K., M., Mergoum, and S. Rajaram (2004).*The history and evolution of triticale*, FAO plant production and protection paper: 179.

Bushuk, W. (2001). Rye Production, chemistry, and technology. Paul, Minnesota. 2**nd** ed.

Bushuk, W. (2004). Rye. University of Manitoba, Winnipeg, M. B., Canada. Elsevier Ltd. All Rights Reserved. *Cited after Encyclopedia of Grain Science*.

Darvey, N. L., H. Naeem and J. P. Gustafson (2000) Triticale: production and Utilization, *Handbook of Cereal Science and Technology*, 2**nd** ed. Marcel Dekker, New York, pp. 257–274.

Donaldson E., W. E. Schillinger, and S. M. Dofing (2001). Straw production and grain yield relationships in winter wheat, *J. Crop Sci*. 41: 100-106.

Elias, E. M., and F. A. Manthey (2005). Durum wheat breeding. Current approaches and future strategies. New York: Food Academic Press, the Haworth Press: 63-86.

FAO (2003). Food Agriculture Organization Statistics, Published online at http/apps fao.org/, FAO, Rome.

FAOSTAT (2012). Food and Agriculture Organization of the United Nations, Database. Accessed 18 May 2012. http://faostat.fao.org/site/567/default.aspx#ancor .

Gibson, L. R. and G. M. Paulson (1999).Yield components of wheat grown under high temperature stress during reproductive development. *Crop Sci*. 39:1841–1846.

Hamid R. B., T. S. Zeinalabedin and A. M. Seyed. (2005). Agronomic Factors on Selected Hulless barley genotype, *J. Of Agron*.4 (4): 333-339.

Hussain S., A. Sajjad, M. I. Hussain and M. Saleem (2001). Growth and yield response of three wheat varieties to different seeding densities. Int. *J. Agric. Biol*.,: 1560-8530.

Jaczewska K.A. (2008). Influence of climatic changes on yielding and cereal protection in Poland. Progress in plant protection, 48 (2): 415-425.

Johansson, E. (2002). Effect of two wheat genotypes and Swedish environment on falling number, amylase activities, and protein concentration and composition. Euphytica, 126: 143–149.

Jolánkal, M., Z. S. Szentpétery and Z. Hegedűs (2006). Pesticide Residue dischange dynamics in wheat grain. *Cereal Res. Communications* 34, 1: 505-509.

Kent, N. L., and A. D. Evers (1994). Kent's Technology of Cereals, 4th edn, Elsevier, Oxford.

Korres, N. E. and R. J. F. Williams (2002). Effects of winter wheat cultivars and seed rate on the biological characteristics of naturally occurring weed flora, J. of Weed research.

Macrae, R., R. K. Robinson, and M. J. Sadler (1993). *Encyclopedia of Food Science, Food Tech. Nutria.*, Academic Press, London.

Madan, H. S. and R. Munjal (2009). Effect of split doses of nitrogen and seed rate on protein content, protein fractions and yield of wheat, ARPN J. of Agri. & Bio. Sci.

Meerza, Ch. H. (2012). Response of Some Triticale and Barley Genotypes for Different Seed Rates. *MSc. In plant Breeding*, University of Sulaimani Faculty of Agricultural Sciences.

Mohammad, F. A., I. Khan, N. U. Maqbool, K. Naz, A. Shaheen, S. and K. Ali, (2011). Comparative Study of Morphological Traits in Wheat and Triticale. *Pak. J. Bot.*, 43(1): 165-170.

Mohammed O. M. (2012). Comparative study of some durum wheat genotypes under the rainfed condition of duhok gover. *Journal Tikrit Univ. For Agri. Sci.* 12: 4.

Peter Koehler and Herbert Wieser (2012). Chemistry of Cereal Grains, Handbook on Sourdough Biotechnology.

Rafique S. M., M. Rashid, M. M. Akram, J. Ahmad, R. Hussain, A. Razzaq (2010). Optimum seed rate of wheat in available soil moisture under rainfed conditions. *J. Agric. Res*. 47(2).

Rajaram, S. (1995). "Yield Stability and Avoiding Genetic Vulnerability in Bread Wheat" Wheat Breeding at CIMMYT: Mexico, DF, CIMMYT. *Wheat Special Report* 29, pp. 11-15.

Ramazan D., O. Kacar, N. Coplu and N. Azkan (2009). Characteristics of new breeding lines of triticale. *African J. of Agri. Res*. 4(2):133-138.

Royo, C., M. Abaza, R. Blanco, and L. F. Garcia del Moral (2000). Triticale grain growth and morphometry as affected by drought stress, late sowing and simulated drought stress. *Aust. J. Plant Physiol*. 27:1051–1059.

Sayre, K. D., S. Rajaram, and R. A. Fischer (1997). Yield potential progress in short bread wheat's in northern Mexico. Crop sci., 37:36-42.

Singh, S. S. (1988). Wheat in Crop management under irrigated and rainfed conditions. *Kalgani Publication, New Delhi:* 23-57.

Tompkins D. K., G. E. Hultgreen, A. I. Wright and D. B. Fowler (1991). Seed rate and row spacing of no till winter wheat. *Agro. J.* 83 (4): 684-688.

Wrigley, C., H. Corke, and C. E. Walker (2004). ENCYCLOPEDIA OF GRAIN SCIENCE. Colin Wrigley, Food Science Australia and Wheat CRC, North Ryde, NSW, Australia.