Genetic Indicators of Barley Cultivars by the Effect of Seeding Rate

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Abstract

A field experiment was carried out during the winter season 2021-2022 in research station 1 - College of Agriculture governorate in Anbar to know the genetic variations between different varieties of barley by the effect of seeding rate. Add was to find the selective indicator for improving barley yield. Split plots arrangement according to randomized complete block design (RCBD) at three replications was used. The main plots included three seeding rates (120, 160 and 200) Kg ha^{-1}, while the subplots included five barley cultivars (Iba 256, Iksad 617, Amal, Samir and Buraq). The results showed that the low seeding rate (120 Kg ha^{-1}) was significantly superior in the flag leaf area (14.45 cm^2). In comparison, the high seeding rate (200 Kg ha-1) was significantly superior in the crop growth rate, weight of 1000 grains, grain yield and biological yield (13.76 g m-2 day-1, 48.21 g,5.78 ton ha-1and 20.48ton ha-1) respectively. In contrast, the seeding rate of 160 Kg ha^{-1} was significantly superior in the harvest index (28.87%) .The yield and its components of barley were studied in terms of performance and variances, and the values of genetic and environmental variances, genetic and phenotypic variance coefficients and heritability in the broad sense were calculated the highest percentages of genetic to environmental variations for the weight of 1000 grains. The highest heritability rates were 99.28% and 98.54% for the biological yield and the weight of 1000 grains, respectively.

Keyword: Barley , yield components, heritability, biological yield, weight grains

المؤشرات الوراثية لأصناف من الشعير بتأثير معدل البذار

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المستخلص

نفذت تجربة حقلية خلال الموسم الشتوي 2021–2022 في محطة رقم 1 التابعة لكلية الزراعة في محافظة الانبار وفق تصميم القطعات الكاملة المعشاة وبترتيب الالواح المنشقة وبثلاث مكررات حيث تم دراسة تأثير ثلاث معدلات بذار (120 و 160 و 200) كغم $هـ^{-1}$ (الالواح الرئيسية) في نمو وحاصل خمسة اصناف من الشعير (آباء 256 و واكساد 617 و امل و سمير و براق) (الالواح الثانوية) , اذ اعطى معدل البذار 120 كغم $هـ^{-1}$ أعلى متوسط لمساحة ورقة العلم بلغ 45.14 $سم^2$, اما معدل البذار 200 كغم $هـ^{-1}$ فقد تفوقت صفات معدل نمو الحاصل ووزن 100 حبة والحاصل البايلوجي والحاصل الكلي حيث بلغو 13.76 غم $م^2$ يوم و 48.21 غم , 20.74 طن $هـ^{-1}$ و5.78 طن $هـ^{-1}$ بالتتابع. اختلفت الاصناف معنويا في اغلب الصفات تفوق الصنف براق أعطاء اعلى متوسط مساحة ورقة العلم وحاصل بايلوجي بلغا 13.86 $سم^2$ و 21.95 طن $هـ^{-1}$ بالتتابع , في حين اعطى الصنفان اكساد و آباء 265 أعلى متوسط للحاصل بلغا 6.01 و 5.87 طن $هـ^{-1}$ بالتتابع تم دراسة صفات الحاصل ومكوناته للشعير من حيث الاداء والتغايرات واحتسبت قيم التغايرات الوراثية والبيئية ومعاملات التغاير الوراثي والمظهري ونسب التوريث بالمعنى الواسع , كانت أعلى نسبة تغايرات وراثية الى البيئية (67 ضعف)لوزن 1000 حبة كانت اعلى نسبة توريث للحاصل البايلوجي ووزن 1000 حبة (99.28% و 98.54%)

الكلمات المفتاحية: الشعير , مكونات الحاصل , التوريث , الحاصل البايلوجي , وزن الحبة.

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Introduction

Barley (*Hordeum vulgare* L.) is one of the essential strategic crops in human and animal nutrition. It is a fast-growing winter cereal crop that tolerates soil salinity and improves its quality. Barley has a high nutritional value because it contains a high percentage of protein and amino acids. It is used in the manufacture of malt and other industries. The production of barley in Iraq for the year 2021 is estimated at 270 thousand tons, with an estimated decrease of 84.8% compared with 2020, which amounted to 1765 thousand tons, as the cultivated area in Iraq of barley for the year 2021 reached 3,092 thousand dunums (Directorate of Agricultural Statistics, 2021). Iraq still faces a large gap between its ability to produce and the amount of consumption, as the relative decline in the cultivation of barley crop and the lack of yield per unit area led to the reluctance of many farmers from cultivating it, which necessitated the work of a developmental program to breed barley plants of different cultivars to know the genetic capability of the cultivars. The success of breeding programs depends on isolating superior genotypes, which depends on the number of genetic variations in the populations. Therefore, determining the variations present in the barley population is very important. Estimating the variance components of quantitative traits is useful in choosing the appropriate and effective method for genetic improvement(Hou et al.,2005, Al-Myal et al.,2020). The different cultivars of barley aren't sufficient alone to raise the productivity of the crop, as it is necessary to determine the optimal seeding rate for the cultivated variety, which makes the variety able to exploit its inherent physiological and genetic capabilities to the highest level to achieve the highest productivity per unit area. Seeding rates are one of the technologies that can influence the growth pattern of the crop and then the yield and its components, depending on the field management conditions and genotype. The seeding rates significantly affect the three main yield components, i.e. number of spikes per unit area, number of grains per spike, and grain weight (Jaddoa and Saleh, 2013; Arya et al., 2019). This research was carried out to know the genetic variations between different varieties of barley by the effect of seeding rate to find selective evidence for improving barley yield.

Materials and Methods

A field experiment was carried out during the winter season 2021-2022 in research station, College of Agriculture to know the genetic variations between different varieties of barley by the effect of seeding rate to find selective evidence for improving barley yield. Split plots arrangement according to randomized complete block design (RCBD) at three replications was used. The main plots included three seeding rates (120, 160 and 200) $Kgha^{-1}$, while the subplots included five barley cultivars (Iba 256, Iksad 617, Amal, Samir and Buraq). Soil management was carried out, and the experiment land was divided into experimental units. The area of each experimental unit was 4 m^2 which contained 10 lines 20 cm apart. Phosphorous fertilizer was added at an amount of 100 Kg ha^{-1} as a DAP at one dose before the planting. In comparison, the nitrogen fertilizer was added at 160 kg N ha^{-1} as urea (46% N) at two equal doses, the first after two weeks of

planting and the second after 45 days of the first dose. The seeds of the barley cultivars were sown on 20 Nov. 2021. Crop management was carried out as needed, and the plants were harvested after the appearance of maturity signs.

Studied traits

1. Flag leaf area (cm^2): It was calculated using the following equation (Sestak et al,1971):

Flag leaf area (cm^2) = leaf length x maximum leaf width x 0.64

2. Crop growth rate (g m^{-2} day^{-1}): It was calculated by dividing the dry matter yield by the number of days from planting to physiological maturity.

3. Weight of 1000 grain (g): one thousand grains were randomly taken from the grain yield of each experimental unit, manually counted, and weighed and the mean weight of 1000 grains was extracted.

4. Grain yield (ton ha^{-1}): A sample of 1 m^2 of each experimental unit was harvested at a humidity of 14%, and the straw was isolated from the seeds, weighed and converted from g m^{-2} to ton ha^{-1}.

5. Biological yield (ton ha^{-1}): A sample of 1 m^2 of each experimental unit was harvested at a humidity of 14%, weighed and converted from g m^{-2} to ton ha^{-1}.

6. Harvest index (%): It was calculated using the following equation:

Harvest index (%) = (Grain yield / Biological yield) x 100

7. Genetic Indicators

$\delta^2G = (\delta^2$ Cultivars $- \delta^2E) / r$ δ^2E= Mse

$\delta^2P = \delta^2G + \delta^2E$

P.C.V = $\sqrt{\delta^2P}$ / Mean of Cultivars

G.C.V = $\sqrt{\delta^2G}$ / Mean of Cultivars

8. The heritability rate (%): The rate of heritability in the broad sense (h^2.b.s) was estimated for the selected traits using the following equation(Pankaj et al., 2015):

h^2.b.s (%) =(δ^2G / δ^2P) x 100

Results and Discussion

Flag leaf area (cm^2)

The results in table 1 show that the Iksad 617 cultivar, superior to others, was significantly superior in the flag leaf area (13.73 cm^2) compared with Samir cultivar, which gave the lowest mean (12.49 cm^2). The reason for the variation of barley cultivars in the flag leaf area may be due to the difference in their genetic composition as well as their difference in the duration from planting until the emergence ejection of spikes in which the growth rate and the expansion of the flag leaf increase (Omar, 2013). Also, the results indicate significant differences between seeding rates in this trait. The low seeding rate (120 Kg ha^{-1})gave the highest mean (14.45 cm^2) compared with the high seeding rate (200 Kg ha^{-1}), which gave the lowest mean (12.11 cm^2) as the effect of competition among plants. The interaction between the two factors had a significant impact on the flag leaf area; the Iksad 617 cultivar, which was planted at a seeding rate of 120 Kg ha^{-1}gavea highest value of 15.50 cm^2 with a non-significant difference with the Iba 265 cultivar which planted at a seeding rate of 120 Kg ha^{-1} which gave 15.28 cm^2. In contrast, the Iba 265 cultivar, planted at a seeding rate of 200 Kg $ha^{-1,}$ gave the lowest value (10.80 cm^2). The results show that the response of the flag leaf area of barley cultivars differed according to the seeding rates. In addition, the percentage of genetic variations in plant populations was higher

than the environmental variations, which gave a relatively good heritability for this trait. This indicates the response of barley cultivars to an increase in the seeding rates. Where are the interpretations of the rest of the genetic criteria.

Table 1. Effect of seeding rate, genetic indicators of barley cultivars on flag leaf area (cm^2)

Seedling Kg ha^{-1}	Cultivars					Mean
	Iba 256	Buraq	Amal	Iksad 617	Samir	
120	14.45	15.28	13.70	13.89	15.50	13.90
160	13.14	14.50	13.00	13.20	13.30	11.68
200	12.11	10.80	12.86	12.57	12.40	11.90
LSD 0.05			0.255			0.454
Mean	13.52	13.19	13.22	13.73	12.49	
LSD 0.05			0.126			
Heritability	$G^2\delta$	$E^2\delta$	P.C.V	G.C.V	Mean	
96.42 %	1.92	0.07133	11.50	11.30	12.27	

Crop growth rate (g m^{-2} day^{-1})

The results in Table 2 reveal that the Buraq cultivar was significantly superior in the (14.85 g m^{-2} day^{-1}) compared with the Amal cultivar, which achieved the lowest mean (11.55 g $m^{-2}day^{-1}$) with a non-significant difference with Iba 265 cultivar (11.57 g m^{-2} day^{-1}**)**. The superiority of Buraq cultivar may be due to its ability to accumulate a high dry matter in a short period. This result is in line with Pankaj et al. (2015). Also, the results indicate significant differences between seeding rates in this trait. The high seeding rate (200 Kg ha^{-1}) achieved the highest mean (13.76g m^{-2} day^{-1}) compared with the low seeding rate (120 Kg ha^{-1}), which reached the lowest mean (11.76g m^{-2} day^{-1}). The early completion of vegetative growth at high crop seeding rates increases the leaf area index. Then it increases the efficiency of light interception, so the photosynthesis process increases and the crop growth rate increases(Abel et al., 2021). The interaction between two factors had a significant effect on this trait; the Amal cultivar, which was planted at a seeding rate of 200 Kg ha^{-1}gave the highest value (15.76g m^{-2} day^{-1}), whereas the Amal cultivar, which was planted at a seeding rate of 120 Kg ha^{-1}achieved the lowest value (10.20g m^{-2} day^{-1})with a non-significant difference with the same cultivar which planted at a seeding rate of 160 Kg ha^{-1} and Iba 265 which planted at a seeding rate of 120 Kg ha^{-1} which achieved 10.79 and 10.88 g m^{-2} day^{-1} respectively. The results reveal that the response of the crop growth rate of barley cultivars differed according to the seeding rates. In addition, the percentage of genetic variations in plant populations was higher than the environmental variations, which gave a relatively good heritability for this trait. This indicates the response of barley cultivars to an increase in the seeding rates, and this means variations in the crop growth rate from one generation to another. These results are in agreement with (Abdulhamed et al., 2022, and Al-Fraih et al., 2015).

Table 2. Effect of seeding rate genetic indicators of barley cultivars on crop growth rate (g m^{-2} day^{-1}).

Seedling Kg ha^{-1}	Cultivars					Mean
	Iba 256	Buraq	Amal	Iksad 617	Samir	
120	11.76	10.88	13.64	10.20	12.37	11.70
160	12.48	11.66	15.14	10.79	12.68	12.11
200	13.76	12.13	15.76	13.65	13.75	13.53
LSD 0.05			0.73			0.42
Mean	13.57	14.85	11.55	12.93	12.45	
LSD 0.05			0.43			
Heritability	$G^2\delta$	$E^2\delta$	P.C.V	G.C.V	Mean	
95.89%	4.288	0.1838	17.32	16.88	12.27	

Weight of 1000 grain (g)

According to research data, the Amal cultivar was significantly superior in the weight of 1000 grains (53.40g) compared with Buraq cultivar, which had the lowest mean (41.15 g). The superiority of amal cultivar could be attributed to its possession of different genes that increased the efficiency of the distribution of photosynthetic products from leaves to grains compared with other cultivars. Also, the results in Table 3 show that the high seeding rate (200 Kg ha^{-1}) was significantly superior in this trait (48.21g) with a non-significant difference with a seeding rate of 160 Kg $ha^{-1,}$ which had 47.82 g. compared with a low seeding rate (120 Kg ha^{-1}) which had the lowest mean (46.17g). This result agrees with(Petkovski et al., 2018), who reported that the weight of 1000 grains was significantly different by the effect of seeding rates. The interaction between two factors significantly impacted this trait; the Amalbcultivar, which was planted at a seeding rate of 160 Kg ha^{-1}hada highest value (53.93g) with a non-significant difference with the same cultivar planted at a seeding rate of 200 Kg ha^{-1} which achieved 53.80g. In contrast, Buraq cultivar, which was planted at a seeding rate of 120 Kg ha^{-1}had the lowest value (40.07g) with a non-significant difference from the same cultivar planted at a seeding rate of 200 Kg ha^{-1}, which had41.55g. The results reveal that the response of the barley cultivars' crop growth rate differed according to the seeding rate difference. Also, the percentage of genetic variations in plant populations was higher than the environmental variations, which gave a relatively good heritability for this trait. This indicates the response of barley cultivars to an increase in the seeding rates, as well as that there is high homogeneity and the heritability rate (98.54%), and this means that there are variations in the weight of 1000 grains from one generation to another.

Table 3. Effect of seeding rate genetic indicators of barley cultivars on the weight of 1000 grain (g).

Seedling Kg ha^{-1}	Cultivars					Mean
	Iba 256	Buraq	Amal	Iksad 617	Samir	
120	46.17	48.56	40.07	52.43	44.34	45.45
160	47.82	49.71	41.78	53.96	45.37	48.28
200	48.21	50.50	41.59	53.80	46.37	48.78
LSD 0.05			1.650			1.082
Mean	49.59	41.15	53.40	45.36	47.50	
LSD 0.05			0.935			
Heritability	$G^2\delta$	$E^2\delta$	P.C.V	G.C.V	Mean	
98.54%	62.70	0.9239	17.00	16.87	46.916	

Grain yield (ton ha^{-1})

The results in Table 4 reveal that the Iksad 617 cultivar was significantly superior in the grain yield (6.01 ton ha^{-1}) compared with the Amal cultivar, which achieved the lowest mean (4.75 ton ha^{-1}). The reason for the variation of barley cultivars in the grain yield may be due to their difference in the yield components, or the reason for the superiority of the Iksad 617 cultivar in the grain yield may be due to its superiority in the flag leaf area (Table 1). These results are consistent with those of (Andost and Al-Dhahiry,2020)), who found a significant difference between barley cultivars in grain yield per unit area. According to the research data, the high seeding rate (200Kg ha^{-1}) achieved the highest mean of grain yield (5.78ton ha^{-1}) with a non-significant difference from the seeding rate of 160 Kg ha^{-1}which to achieved 5.58ton ha^{-1}compared with the seeding rate of 120Kg ha^{-1}which achieved the lowest mean (5.08ton ha^{-1}). The reason for the high seeding rate (200 Kg ha-1) in the grain yield could be attributed to its superiority. The interaction between two factors had a significant effect on the grain yield; the Iksad 617 cultivar, which was planted at a seeding rate of 200 Kg ha^{-1}gave the highest value (6.36 ton ha^{-1}) with a non-significant difference with the Iba 265 cultivar which planted at a seeding rate of 200 Kg ha^{-1} which gave 6.14 ton ha^{-1}. In contrast, the Amal cultivar, which was planted at a seeding rate of 120 Kg ha^{-1}achieved the lowest value (4.54ton ha^{-1})with a non-significant difference from the same cultivar planted at a seeding rate of 160 Kg ha^{-1}and Samir cultivar, which planted at a seeding rate of 120 Kg ha^{-1}which achieved4.56 and 4.76ton ha^{-1} respectively. It is noticed from the data that the response of the grain yield of barley cultivars differed according to the difference in seeding rates. In addition, the percentage of genetic variations in plant populations was higher than the environmental variations, which achieved a relatively good heritability for this trait. This reveals the response of barley cultivars to an increase in the seeding rates, which means variations in the grain yield from one generation to another.

Table 4. Effect of seeding rate genetic indicators of barley cultivars on grain yield (ton ha^{-1}).

Seedling Kg ha^{-1}	Cultivars					Mean
	Iba 256	Buraq	Amal	Iksad 617	Samir	
120	18.22	15.40	20.50	20.20	18.00	17.00
160	19.72	17.20	22.16	20.80	20.60	17.86
200	20.48	17.66	23.20	21.71	21.00	18.83
LSD 0.05			0.698			0.638
Mean	16.75	21.95	20.90	19.87	17.90	
LSD 0.05			0.305			
Heritability	$G^2\delta$	$E^2\delta$	P.C.V	G.C.V	Mean	
99.28%	13.64	0.09826	19.05	18.98	19.456	

Biological yield (ton ha^{-1})

The results in Table 5 show that the Buraq cultivar was significantly superior in the biological yield (21.95 ton ha^{-1}) compared with Iba 265 cultivar, which gave the lowest mean (16.75 ton ha^{-1}). The superiority of the Buraq cultivar in the biological yield may be due to its ability to increase its vegetative growth and the length of the physiological maturity of the cultivar, which caused an increase in the production of dry matter. These results are consistent with results(Aklilu et al., 2020). Also, the results indicate significant differences between seeding rates in this trait. The high seeding rate (200 kg ha^{-1})gave the highest mean (20.48 ton ha^{-1}) compared with the low seeding rate (120 kg ha^{-1}), which provided the lowest mean (18.22 ton ha^{-1}). The reason for the superiority of the seeding rate of 200 Kg ha^{-1}in the biological yield could be attributed to its superiority in the crop growth rate (Table 2), the weight of 1000 grains (Table 3) and grain yield (Table 4). This result agrees with(Abdulhamed et al.,2021b). The interaction between two factors had a significant effect on the biological yield; the Buraq cultivar, which was planted at a seeding rate of 200 Kg ha^{-1}gavea the highest value (23.20 ton ha^{-1}), whereas the Iba 265 cultivar, which was planted at a seeding rate of 120 Kg ha^{-1}gavea lowest value (15.40 ton ha^{-1}). The results indicate that the response of the biological yield of barley cultivars differed according to seeding rates. In addition, the percentage of genetic variations in plant populations was higher than the environmental variations, which gave a relatively good heritability for this trait. This indicates the response of barley cultivars to an increase in the seeding rates, and this means variations in the biological yield from one generation to another.

Table 5. Effect of seeding rate genetic indicators of barley cultivars on biological yield (ton ha^{-1})

Seedling Kg ha^{-1}	Cultivars					Mean
	Iba 256	Buraq	Amal	Iksad 617	Samir	
120	5.08	5.40	5.13	4.54	5.57	4.76
160	5.58	6.07	5.71	4.56	6.10	5.48
200	5.78	6.14	5.83	5.14	6.36	5.43
LSD 0.05			0.24			0.24
Mean	5.87	5.56	4.75	6.01	5.22	
LSD 0.05			0.13			
Heritability	$G^2\delta$	$E^2\delta$	P.C.V	G.C.V	Mean	
97.70%	0.85	0.020	17.01	16.83	5.482	

Harvest index (%)

Iba 265 cultivar was significantly superior in the harvest index (34.69%) compared with the Amal cultivar, which had the lowest mean (22.30%). The reason for the variation of barley cultivars in the harvest index may be due to their difference in grain yield and biological yield, as the cultivars vary in their efficiency in distributing photosynthesis products from source to sink. This result agrees with other researchers who noted a significant difference between the cultivars in the harvest index(Shendy, 2015; Fadel et al., 2022). Also, the results in table 3 show that the seeding rate of 160 Kg ha^{-1} was significantly superior in the harvest index (28.87%) with a non-significant difference with a high seeding rate (200 Kg ha^{-1}), which had 28.16% compared with a low seeding rate (120 Kg ha^{-1}) which had the lowest mean (27.65%). This result is in line with the results of(Aklilu and Worede, 2020). The interaction between two factors had a significant effect on this trait; the Iba 265cultivar which was planted at a seeding rate of 160 Kg ha^{-1}had the highest value (35.69%) with a non-significant difference with the same cultivar planted at the seeding rates of 120 and 200 Kg ha^{-1} which achieved 33.80 and 34.57%, respectively as well as Iksad 617 cultivar which planted at a seeding rate of 160 Kg ha^{-1} which had 32.11%, while Amal cultivar which planted at a seeding rate of 160 Kg ha^{-1}had the lowest value (21.92%)with a non-significant difference with the same cultivar which planted at the seeding rates of 120 and 200 Kg ha^{-1} which had 21.99 and 22.99%, respectively. The results show that the response of the harvest index of barley cultivars differed according to the seeding rates. Also, the percentage of genetic variations in plant populations was higher than the environmental variations, as the ratio of genetic to environmental variations was 12.7 times, giving a relatively good heritability for this trait. This indicates the response of barley cultivars to an increase in the seeding rates, and this means variations in the harvest index from one generation to another. This result agrees with the results of Sapi and Bhattaeharjee (2017) and Pal et al. (2018).

Table 6. Effect of seeding rate genetic indicators of barley cultivars on harvest index (%).

Seedling Kg ha^{-1}	Cultivars					Mean
	Iba 256	Buraq	Amal	Iksad 617	Samir	
120	27.65	33.80	24.84	21.99	31.09	26.54
160	28.87	35.69	26.10	21.92	32.11	28.52
200	28.16	34.57	25.53	22.99	30.94	26.75
LSD 0.05			2.280			1.11
Mean	34.69	25.49	22.3	31.38	27.27	
LSD 0.05			3.68			
Heritability	$G^2\delta$	$E^2\delta$	P.C.V	G.C.V	Mean	
92.68%	69.54	5.490	30.69	29.55	28.224	

Conclusion

It can be concluded that barley cultivars responded to seeding rates, as indicated by the high heritability in most traits, low environmental influences, and the presence of phenotypic homogeneity resulting from the genetic variation coefficient. Therefore, we recommend adopting the crop growth rate, the weight of the grain and the biological yield in evaluating the productive capacity of the grains in the selection programs under the influence of seeding rates. On the other hand, the coincidence of increasing the genetic indicators with genetic progression is important for selection to improve certain traits.

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