EFFECTS OF SOWING DATE AND LOCATIONS ON THE SELECTED WHEAT CULTIVARS QUALITY PERFORMANCE

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ABSTRACT

The current study was aimed assessing the effects of cultivars, sowing date and locations on bread wheat (*Triticum aestivum* L) quality parameters grain protein concentration (GP), Gluten Index GI, falling number (FN), Water absorption capacity (WAC %), Pasting temperature (PT), and loaf volume (LV) of five bread wheat cultivars viz. Alla, Hassad, Charmo, Maaroof, and Adana as control, two sowing dates (Nov 15th, Dec 15th) at each location under rainfed environment. Grain samples were obtained from previous field experiments were conducted at two locations of Sulaimani Governate in Iraq-Kurdistan-region, Qlyasan and Halabja, during growing seasons 2018-2019. The experiments were conducted using RCBD within split plot arrangement with three replicates. Result for companied analysis, showed that cultivars sowing date, locations, the interactions CS, CL, and SL and tri-interaction CSL were high significantly affects to all quality traits except GP for location, LV for SL and GP for CS interaction, which were non-significant. The results confirmed that sowing wheat lately is an accept option for maximizing GP, GI, PT, and LV, while, optimum sowing was increasing FN and WA traits, regardless of cultivar or location. Wheat grown at Qlyasan appeared to have more GP content, FN, WA, PT, and LV, while Halabja location to have stronger gluten quality (GI). The di-interactions viz. CS, CL, and SL and tri-interaction CSL played a significant important role in changing or modifying the values of the quality traits.

Key words: wheat, cultivars, quality, sowing date, location.

*** Parts of MSc. of the 1st author**

مجلة العلوم الزراعية العراقية- 2024:55(5):1813-1825 عبدالله وآخرون

تأثير موعد الزراعة والمواقع على أداء صفات نوعية مختارة لأصناف الحنطة

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المستخلص

هدفت الدراسة الحالية إلى تقييم تأثير الأصناف وموعد الزراعة والمواقع على معايير جودة حنطة الخبز، بروتين الحبوب (GP)، مؤشر الغلوتين GI، رقم السقوط (FN)، سعة امتصاص الماء (WAC٪)، درجة حرارة تهلم النشأ (PT)، وحجم اللوف (LV) لخمسة أصناف من حنطة الخبز. آلاء، حصاد، جرمو، معروف، ادنة كصنف مقارنة، موعدي بذار (15 ت2، 15 ك 1) في كل موقع تحت الظروف المطرية. تم الحصول على عينات الحبوب من تجارب حقلية سابقة أجريت في موقعين بمحافظة السليمانية في إقليم كردستان العراق هما قليسان وحلبجة خلال الموسم الزراعي 18-2019. أجريت التجارب بتصميم RCBD بترتيب القطع المنشقة بثلاث مكررات. أظهرت نتائج التحليل التجميعي أن الأصناف وموعد البذار، والمواقع، والنداخلات الثنائية كـ CS وCL وSL والتداخل الثلاثي CSL كان لهم تأثيرًا معنويا عاليا على جميع سمات الجودة عداLV لتداخل SL وGP لتداخل CS والتي كانت غير معنوية. أن تأخير موعد بذار الحنطة هو خيار مقبول لتعظيم GP وGI وPT وLV، بينما كان البذار الأمثل لتحسين صفات FN وWA بغض النظر عن الصنف أو الموقع. أن الحنطة المزروعة في موقع قلياسان ادت الي ارتفاع قيم GP وFN وWA وPT و LV. في حين أن موقع حلبجة تمتع بجودة غلوتين أقوى (GI). ادت التداخلات الثنائية CS وCL وSL والثلاثية CSL دورًا معنويا في تغيير أو تحوير القيم لسمات الجودة.

الكلمات المفتاحية: الحنطة، الأصناف، النوعية، موعد الزراعة، المواقع

* جزء من رسالة الماجستير للباحث الاول

Received:22/4/2022, Accepted:17/7/2022

INTRODUCTION

Wheat is the most widely adapted and cultivated crop worldwide, and it is the principal cereal for temperate regions. In the genus Triticum, there are numerous species and subspecies. The most important are common wheat (*Triticum aestivum*), which accounts for over 90% of global wheat (21), with an annual production of about 739.9 million tons (19). The prime cause for the domination of wheat in a wide area of temperate regions is the unparalleled viscoelastic features of its dough that allows its flour to be processed into an extent of products starting from bread and then cakes, biscuits, pasta, noodles, and numerous else products (46). Within a species, wheat cultivars have significant differences in grain composition and processing quality (4, 9). Quality differences among wheat cultivars have become even more important in grain trading (16, 17, 41). Sowing dates, rates and locations represent the main growing conditions (10, 35). The storage proteins composition of wheat is complex and genetically specific through the glutenin and gliadin alleles. The alleles expression is largely controlled by the environmental conditions (E) as well the interaction of every genotype with the growing conditions (G x E) leading to broad variation in the composition of protein. (13, 14). Abiotic stresses, such as high temperatures, water deficits, and drought, have a significant impact on wheat grain filling and quality by affecting both nitrogen and carbon metabolism (25). Wheat bread-making quality traits are complicated and influenced by a combination of environmental and genetic factors. Naraghi *et al*. (30), also cultivar and climatic conditions are the main determinants of wheat quality (3, 5, 40). The quality of wheat grain is influenced by various factors: environmental, genetic factors, crop management practices, and their interactions among those factors (12). The success of any crop depends on optimal management in terms of service operations and an abundance of growth factors, especially varieties appropriate to the environment and sown with appropriate dates, which increases the proportion per unit area due to the role of climatic conditions in affecting physiological processes in the plant, rates of growth, and the period of its entire lifecycle (42). Sowing during the first half of December in Mediterranean environments results in variability in flowering time. The aim of this study is to assess the impact of some bread wheat cultivars, sowing date, and important wheat productive of the Kurdistan-Iraq region on wheat end-use quality traits and provide valuable information for breeding purposes.

MATERIALS AND METHODS

Grain samples were obtained from previous experience of five bread wheat cultivars grown in 2018 -2019 at two different locations in Iraq-Kurdistan-region, Qlyasan and Halabja. The varies environments represented adequate range of environmental conditions (Table I). The 5 wheat cultivars used in this study were Alla (C_1), Hasad (C_2), Charmo (C_3), Maaroof (C_4) and Adana (C_5) as a control. All cultivars were suitable for agronomically production in the locations in question. The wheat cultivars were planted in a randomized complete block design with three replicates at each location. Plots of 5 m^2 with 10 rows spaced 20 cm apart were seeded at a rate of 140 kg/ha. Quality tests were implemented on the harvested grains of each cultivar for each replicate. The experiments were conducted in a randomized complete block design (RCBD) within a split-plot arrangement with three replications of two factors: sowing date was the main plot, and cultivars was the subplot. The size of the plot is 2 m^2 (with two rows of 5 meters each and 0.2 meters apart were seeded at a rate of 140 kg/ha. Quality tests were implemented on the harvested grains of each cultivar for each replicate. Collected data were statistically analyzed using XLSTAT-2016. The revised LSD was done to determine the significant difference among means at the 0.05 significance level.

Quality Analyses

The quality characteristics of wheat tested contained those relevant to grain, dough and bread as mentioned below. Wheat grain protein concentration (GPC) was determined by Perten IM 9500 Near Infrared Reflectance (NIR) according to AACC methods NO.55-10.01, 2000., Gluten Index GI: according to AACC method No. 30.12.02 (1)., The falling number (FN) second using the Official Method

56–81.03 (1), Water absorption capacity (WAC %) was determined by using AACC Approved Methods of Analysis, 11th Ed, Method 54-21.02 (1), Pasting temperature (PT°C) according to AACC method No.61-01 (1) and the volume of a loaf (LV) cm^3 was measured by the rapeseed displacement method in a loaf volume meter (1).

environments tested in Sulaimani Kurdistan-Iraq

Location	Environment Sowing date	Latitude LongitudeMasl	Soil properties	Rainfall (mm)
Qlyassan	normal sowing date S1 15/11/2018 Late sowing date S2 15/12/2018	35°34’N 45°22’E 765	pH =7.89, Silt-Clay	1317.2
Halabja	normal sowing date S1 15/11/2018 Late sowing date S2 15/12/2018	35°10’N 45°59’E 721	pH = 7.99, Clay	1081.4

RESULTS AND DISCUSSIONS

Grain protein (GP) (%): It is well known that grain protein content (GP) influences the functional characteristics of processed wheat products. It is an essential parameter studied in order to evaluate the quality attributes of wheat varieties (49). The analysis of variance, as observed in Table (2), show that the mean square of cultivars V for both locations and sowing dates S for L_1 only due to GP% were extremely significant, demonstrating high variances among their means.

Table 2. Analysis of variance of the studied characters for each location and across locations

S.O.V.	D.F	M.S GP	GI	FN	WA	PT	LV
Qlyasan Location (L_1)							
Cultivars (C)	4	4.385**	3065.467*	5925.950**	23.005**	24.721**	234.450 ns
Sowing Dates (S)	1	5.547**	388.800 ns	39821.633**	11.719 ns	7.008 ns	480.000 ns
CS	4	0.241 ns	4069.967*	4932.883*	4.245 ns	7.571*	973.417*
E	18	0.123	906.263	1103.959	2.715	2.305	221.311
Halabja Location (L_2)							
C	4	4.814**	5402.633**	5710.383**	20.843 ns	25.075 ns	993.000**
S	1	0.027 ns	1936.033**	19917.633**	107.163**	158.700**	333.33*
CS	4	0.263 ns	532.200*	3941.717*	31.160*	57.658*	210.333*
E	18	0.163	122.630	886.652	8.541	13.553	62.781
Combined Locations							
Locations (L)	1	12.696*	6020.02**	36704.3**	54.055*	65.1042**	1995.27**
L/R	4	0.682	2.31667	5.38333	6.96904	0.20417	16.1667
S	1	2.4**	294.817**	1728.07**	24.0034**	116.204**	806.667**
S*L	1	3.174**	2030.02**	57908.3**	94.8784**	49.5042**	6.66667 ns
C	4	8.29192**	7340.17**	1917.06**	34.4287**	35.0042**	141.475**
C*L	4	0.90642**	1127.93**	9722.14**	9.41921**	14.7917**	1085.98**
C*S	4	0.10625 ns	3736.4**	7359.78**	23.0775**	18.6**	498.875**
C*S*L	4	0.39775**	865.767**	1523.23**	12.3284**	46.6292**	684.875**
E	36	0.08719	3.09	8.96	1.6939	0.6810	10.519
Total	59						

GP: Grain Protein, GI: Gluten Index, FN: Falling Number, WA: Water Absorption, PT: Pasting Temperature, LV: Loaf Volume

*** = Significant at P = 0.05, ** = Significant at P = 0.01.**

The data in Table 3 shows that the value of GP% varied from C_3 (13.10) to C_1 (10.98%) for L_1 while, at L_2 varied from C_3 (12.48), to C_4 (10.26%). According to the results in the same Table, the GP% on the S_2 is 12.26% higher than the GP% on the S_1 at Qlyasan location.

Table 3. Effect of wheat cultivars, sowing dates, and their interaction on quality characters at two locations

Trait	Pc		GI		FN		WA		PT		LV	
Location	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2	L1	L2
Cultivar (C)												
C1	10.98	10.71	48.83	37.67	587.1	555.8	78.91	78.71	67.5	63.67	142.7	127
C2	11.23	10.46	5.67	26.67	562.8	569.0	79.84	79.85	66.75	62.25	139.3	136
C3	13,1	12.48	27.17	47.67	600.3	558.1	83.85	81.30	63	62.42	147.7	121
C4	11.58	10.26	44.33	85.5	646.6	501.0	79.56	76.98	68.25	65.92	133.8	151
C5	12.25	10.61	65.5	94.67	616.1	581.5	81.16	77.00	65.92	66.75	149.2	120
LSD 0.05	0.426	0.490	32.52	13.43	40.30	36.18	1.998	ns	1.841	ns	ns	9.611
Sowing date (S)												
S1	11.4	10.94	42	50.4	639.1	527.3	80.04	80.66	65.8	61.9	138.5	127.7
S2	12.26	10.84	34.8	66.47	566.2	578.9	81.29	76.88	66.77	66.5	146.5	134.3
LSD 0.05	0.269	ns	Ns	8.495	25.48	22.84	ns	2.242	ns	2.824	ns	6.078
CxS interaction												
C1xS1	10.5	11.07	8	14	611.6	538.3	79.63	82.53	66.67	62.17	137.3	115
C1xS2	11.47	10.37	89.67	61.33	562.7	573.3	78.20	74.90	68.33	65.17	148	139
C2xS1	10.53	10.57	8	19	582.7	534.0	79.15	84.10	66.83	60.83	122.3	137.3
C2xS2	11.93	10.37	4.33	34.33	543	604.0	80.53	75.60	66.67	63.67	156.3	134.7
C3xS1	12.93	12.37	45.33	43	606.7	512.3	82.30	83.27	63.67	54.67	154	117
C3xS2	13.27	12.6	9.0	52.33	594.0	604.0	85.40	79.33	62.33	70.17	141.3	125
C4xS1	11.11	10.27	60.33	69.67	701.3	455.3	78.53	75.70	68.17	65.17	138.7	154
C4xS2	12.07	10.27	28.33	91.33	592.0	546.7	80.08	78.27	68.33	66.67	129	148
C5xS1	11.93	10.41	88.33	96.33	693.0	596.7	80.06	77.70	63.67	66.67	130.3	115
C5xS2	12.57	10.8	42.67	93	539.3	566.3	81.73	76.30	68.17	66.83	168	125
LSD 0.05	Ns	ns	51.64	19	57	50.08	ns	5.013	2.604	6.315	25.52	13.59

For the combined analysis, (Table 2) shows the combined analysis exhibited highly significant mean squares due to sowing dates S, cultivars C, cultivars C x location L interaction, sowing dates S x location L interaction, and tri-interaction among cultivars C x sowing date S x location L interactions, indicating significant differences between their means. However, the significant mean square for location L. According to the Table (4), there was a significant difference between C due the GP% trait. The C_3 has the highest GP% content (12.79%). The least amount of GP% (10.85%) was recorded by C_1 and C_2. Saudi and Al- Hassan (45) noticed range was (12.25-14.25) protein content for four Iraqi cultivars. The investigation is comparable to (6). Significant differences found between the 2S for GP%. The value at S_2 (11.57%) is higher than the value at S_1 (11.17%). The result was supported by (8), they found there were a gradual significant rising in PC% with delayed S_1 to S_4 for triticale crop. According to (6), the increases in protein percentage for the late appointment is to give it the lowest grain weight (6). The amount of GP% in the L_1 is 11.83% higher than in the L_2. The effect of L on this character was also observed by (24). The interaction of (C ×S) on GP% didn't show a significant difference. This finding was consistent with what was found by (28). Regarding significant differences between the C × L interaction due to the GP%. $C_3 \times L_1$ (13.10%) is the greatest value of them all. Nonetheless, $C_4 \times L_2$ (10.27%) is the smallest value, these results are in agreement with (24). The protein composition of genotypes was primarily influenced by environmental factors, as well as the interaction of genotype and environment (50). According to the interaction of S × L, there was a significant variation between them. 12.26% is the maximum value of GP (%) on $S_2 \times L_1$. Although 10.88% at the same sowing S_2 × Halabja L_2 is the minimum value, the same result was found by (2). The C × S × L tri-interaction effect on GP (%) was significant. For $C_3 \times S_2 \times L_1$, the value was 13.27%, the highest rate of GP%, whereas the $C_4 \times S_1 \times L_2$ and $C_4 \times S_2 \times L_2$ had the lowest GP% of 10.27%. This outcome of tri-interactions doesn't agree with the results of Ahmed (2). Throughout this research, it could be concluded that, the Charmo C_3 had superior cultivar in particular the treatment C_3 S_2 L_1, higher protein quantity, which are considered good indicators for wheat grain soundness. Late sowing S_2 (December 15th) had a positive effect on GP% compared to normal sowing (November 15th). The GP% in the L_1 is greater than in the L_2.

Table 4. Effect of wheat cultivars, sowing dates, locations, and their interaction on grain protein (GP) (%)

Locations (L)	Sowing date (S)	cultivars (C) Alla (C1)	Hasad (C2)	Charmo (C3)	Maaroof (C4)	Control Adana (C5)	L* S
Qlyasan	S1	10.50 hi	10.53 hi	12.93 ab	11.10 fg	11.93 de	11.40 b
L1	S2	11.47 ef	11.93 de	13.27 a	12.07 d	12.57 bc	12.26 a
Halabja	S1	11.07 fg	10.57 hi	12.37 cd	10.27 i	10.43 hi	10.94 c
L2	S2	10.37 hi	10.37 hi	12.l60 bc	10.27 i	10.80 gh	10.88 c
L1		10.98 de	11.23 d	13.10 a	11.58 c	12.25 b	11.83 a
L2		10.72 ef	10.47 fg	12.48 b	10.27 g	10.62 f	10.91 b
S1		10.78	10.55	12.65	10.68	11.18	11.17 b
S2		10.92	11.15	12.93	11.17	11.68	11.57 a
V Mean		10.85 c	10.85 c	12.79 a	10.93 c	11.43 b	

LSD 0.05: C =0.2444, S=0.1546, L =0.5920, S *C =N.S., L*C =0.3457, L*S =0.2186, L*S*C =0.4889
*** Each value represents the mean of three replications.**
**** Different letters inside the column displays significant differences among the treatment means at (P≤0.05) according to LSD's multiple range tests.**

Gluten index (GI) (%): The analytical parameter of wheat protein that determines both the quality and quantity of gluten at the same time is the gluten index (GI) (1). According to Table (2), which declared the analysis of variance, the mean square of cultivars (C), sowing dates (S) and the interaction between cultivars and sowing date (C × S) were significant to highly significant for both locations with except S for L_1, demonstrating large variations among their means or values. As shown in Table 3, the gluten index (GI) percentages of the studied five wheat cultivars, notice that the maximum was recorded by the Adana (control) C_5 cultivar (65.5%), and the minimum was recorded by Hasad C_2, which was 5.67%, while other cultivars had approximately similar ranges of (Alla C_1, Maaroof C_4, and Charmo C_3) with (48.83%, 44.33%, and 27.17%), respectively for L_1. While at L_2, the Adana (control) C_5 had the highest gluten index GI with 94.67%, and similarly, L_1, the smallest ratio recorded by Hasad C_2, had 26.67%. Further cultivars were Maaroof C_4 (85.5%), Charmo C_3 (47.67%), and Alla C_1 (37.67). The average wheat cultivar at late sowing S_2 (66.47%) surpassed normal sowing S_1 (50.40%). The interaction of C × S illustrated that ($C_1 \times S_2$) gave the highest value (89.67%) and ($C_2 \times S_2$) gave the lowest (4.33%) at Qlyasan location, while there were 96.33% and 14% for (C_5 S_1) and (C_1 S_1), respectively at Halabja location. Cultivars have a significant impact on the GI% value at each location. For the combined analysis, As observed in (Table 2), cultivars (C), sowing dates (S), locations (L), C x S interaction, C x L interaction, S x L interaction, and interaction among C x S x L, all showed highly significant mean squares, indicating significant differences in their means. The results, illustrates in Table 5, show that the mean of Adana (control) C_5 cultivars has the highest (80.08%) among tested cultivars, while Hasad C_2 has the lowest (16.42%). The others of the cultivars were Maaroof C_4, Alla C_1, and Charmo C_3 with (64.92%, 43.25%, and 37.42%), respectively. This is consistent with those by (7). GI parameter has a value between 0 and 100, with a value between 65 and 80 being optimal. Values greater than 80 indicate high gluten content. A gluten with moderate to strong initial proteolytic activity has a value of less than 65 (37). According to the sowing date results, the late sowing was 50.63% higher than the normal sowing, which was 46.20%. These findings are in close agreement with (15), who declared that GI increases with a delay in sowing. Regarding the two locations, L_2 was greater by 58.43% than L_1, which was 38.40%. This is in line with the results found by (7). Migliorini *et al* (37) found that gluten quality, as measured by GI, was found to be nearly optimal, but was influenced by environmental conditions (sowing date and location). The GI% for the C × S interaction ranged from 92.33% to 11.00%, with the highest for $C_5 \times S_1$ and the lower C_1 cultivars on the same sowing. Mahdavi *et al* (33) reported the C × S interaction having a substantial difference. According to the C x L interaction, $C_5 \times L_2$ was 94.67% of the maximum, while $C_2 \times L_1$

was 6.17% of the minimum average. Significant influences on GI% was recorded, similar to this result by (32). The result revealed the interaction of S × L. The highest was recorded by $S_2 \times L_2$ (66.47%) and the lowest was recorded at the same sowing and L_1 was 34.80%. As well as the tri-interaction cultivars, the value of $C_5 \times S_1 \times L_2$ was 96.33%, the greatest among them, while $C_2 \times S_2 \times L_1$ had the smallest value of 4.33%. Considering the results of this study, it was concluded that cultivar environmental (sowing date and location) conditions have a high influence on GI%. It was found the Adana or (control) C_5 cultivar had the maximum gluten index, which is categorized as strong flour. Late sowing S_2 and Halabja L_2 location are better than normal sowing S_1 and Qlyasan location. There were significant effects of (C S), (C L), (S L) and (C S L) interactions.

Table 5. Effect of wheat cultivars, sowing dates, locations and their interaction on Gluten index %

Locations (L)	Sowing date (S)	Cultivars (C)					S* L
		Alla (C1)	Hasad (C2)	Charmo (C3)	Maaroof (C4)	Control (C5)	
Qlyasan	S1	8.00 m	8.00 m	45.33 h	60.33 f	88.33 d	42.00 c
L1	S2	89.67 cd	4.33 n	9.00 m	28.33 j	42.67 h	34.80 d
Halabja	S1	14.00 l	19.00 k	43.00 h	79.67 e	96.33 a	50.40 b
L2	S2	61.33 f	34.33 i	52.33 g	91.33 bc	93.00 b	66.47 a
L1		48.83 d	6.17 h	27.17 g	44.33 e	65.50 c	38.40 b
L2		37.67 f	26.67 g	47.67 d	85.50 b	94.67 a	58.43 a
S1		11.00 j	13.50 i	44.17 f	70.00 c	92.33 a	46.20 b
S2		75.50 b	19.33 h	30.67 g	59.83 e	67.83 d	50.63 a
C Mean		43.25 c	16.42 e	37.42 d	64.92 b	80.08 a	

LSD 0.05: C=1.4564, S=0.9211, L=1.0911, C*S=2.0597, C*L=2.0597, S*L=1.3027, C*S*L=2.9129

Falling number (FN) (seconds): A falling number indicates that starch damage has occurred while enzymatic activity has increased over the storage period. It is important because there is a direct relationship between enzyme activity and final product features like loaf volume, bread crumb quality, etc. (34). Nevertheless, (32) illustrated its use as a substrate for dough fermentation. The analysis of variance (Table 2) showes the mean square of cultivars (C) and sowing date (S) had a highly significant effect, indicating that they were highly different among their means and was significant for interaction between C × S for the falling number FN trait for both locations. The result in Table 3 shows that the Maaroof C_4 (646.6 seconds) achieved the highest, followed by Adana (control) C_5 (616.1 seconds), Charmo C_3 (600.3), Alla C_1 (587.1 seconds) and Hasad C_2 which recorded the lowest among studied cultivars, which was 562.8 seconds. The normal sowing date S_1 of 639.1 is higher than the late sowing date S_2, which had 566.2 seconds. According to the interaction between C × S interaction, the Maaroof on the normal sowing date, $C_4 \times S_1$ with 701.3 reaching the highest, and $C_2 \times S_2$ with 543 seconds reaching the lowest for L1. While for L2, the FN of seconds indicates which were gained from the longest seconds to the shortest for Adana (control) C_5 and Maarooof C_4 (581.5 to 501 seconds), respectively, and which were on par with Hasad C_2 (569), Charmo C_3 (558.1), and Alla C_1 (555.8) seconds. The mean wheat cultivar value at the late sowing date S_2 of 578.9 surpassed the normal sowing S_1 of 527.3 seconds significantly for a falling number. The results of the interactions between C × S, where the $C_2 \times S_2$ and the $C_3 \times S_2$ gave the highest values. Nevertheless, the ($C_4 \times S_1$) gave the lowest value, with 604 and 455.3 seconds, respectively. From the combined analysis, showed highly significant mean squares due to all factors, which include cultivars (C), sowing dates (S), locations (L), C x S, C x L, S x L, and C x S x L interactions, indicating big variations in their means (Table 2). The means of the falling number of seconds for cultivars are show in Table 6. The Control or Adana C_5 cultivar registered the largest time mean of FN, with 598.8 seconds, while the Hasad C_2 cultivar recorded the shortest time of 565.9 seconds. And the other cultivars were Charmo C_3 at 579.3 seconds, Maaroof C_4 at 573.8 seconds, and Alla C_1 at 571.7 seconds. These results are supported by (47). Babiker *et al* (11) demonstrated the dissimilarity in cultivars' mean values is related to variances among them in the grain size. The falling number was evaluated for enzymatic activity, if the falling number was below 150, it means that it had higher enzymatic activity and viscous crumb of bread. When the falling number is between 200 and 300, the enzymatic activity is optimal and the crumbs of bread are excellent. Nine Iraqi promising lines and cultivars were documented as good with range (286-315 FN). The optimum planting (S_1) is longer, at 583.3 seconds, than the late planting (S_2), at 572.5 seconds. According to the locations (L), the Qlyassan L_1 gave an average of 602.6 seconds longer than the Halabja L_2 of 553.3 seconds. A substantial difference was found between the two locations, as agreed with (44). Differences in environmental and soil nutritional factors between the two locations may account for the significant effect of location on the falling number (11). In terms of cultivar-sowing-date interactions, C_5 x S_1 yielded the highest value of 644.8 seconds, although the same cultivar on the late sowing yielded the lowest value of 552.8 seconds. This is in line with (21). $C_4 \times L_1$ had the highest significant, while the same cultivar on Halabja had the lowest, with 646.7 and 501.0 seconds, respectively. The results presented here demonstrate that C × L interaction influenced pointedly, as found (25). According to (11), the environment has a greater influence on the falling number of cultivars than the cultivar-environment interaction. The highest interactions of S × L was 639.1 seconds on the $S_1 \times L_1$, and the lowest was 527.5 seconds on the same sowing date and the Halabja location. Regarding tri-interactions among them, similarly above, they varied significantly, ranging from $C_4 \times S_1 \times L_1$ to the same cultivar on the same sowing date and at the Halabja location with 701.3 and 455.3 seconds. Regarding our result of a significant differences the S × L and the C × S × L this result is in disagreement with (28) finding. According to that falling number is between 200 and 300, the enzymatic activity is optimal, it was concluded that the three factors and their interactions were made a significant change in filling number trait. Then the best treatments performances were for the means of C_2 (565.9), S_2 (572.5, L_2 (553.2), C_4 x S_2 (552.8), C_4 x L_2 (501.0), S_1 x L_2 (527.5) and the value of C_4 x S_1 x L_2 (455.3) second.

Table 6. Effect of wheat cultivars, locations, sowing dates, and their interaction on falling number (sec)

Locations (L)	Sowing date (S)	cultivars (C)					
		Alla (C1)	Hasad (C2)	Charmo (C3)	Maaroof (C4)	Adana Control (C5)	S* L
Qlyassan L1	S1	611.7 c	582.7 f	606.7 d	701.3 a	693.0 b	639.1 a
	S2	562.7 h	543.0 ij	594.0 e	592.0 e	539.3 j	566.2 c
Halabja L2	S1	539.0 j	534.0 k	512.3 l	455.3 m	596.7 e	527.5 d
	S2	573.3 g	604.0 d	604.0 d	546.7 i	566.3 h	578.9 b
L1		587.2 d	562.8 g	600.3 c	646.7 a	616.2 b	602.6 a
L2		556.2 h	569.0 f	558.2 h	501.0 i	581.5 e	553.2 b
S1		575.3 cd	558.3 f	559.5 f	578.3 c	644.8 a	583.3 a
S2		568.0 e	573.5 d	599.0 b	569.3 e	552.8 g	572.5 b
C Mean		571.7 c	565.9 d	579.3 b	573.8 c	598.8 a	

LSD 0.05: C=2.4780, S=1.5672, L=1.6632, C*S=3.5044, C*V=3.5044, S*L=2.2163, C*S*L=4.9560

Pasting temperature (PT)°C: The analysis of variance as declared in Table (2) shows that the mean square of cultivars (C) at L_1, sowing date is highly significant at L2, and cultivars sowing date interaction were highly significant and significant at L_1 and L_2, respectively, demonstrating a high difference between their means. According to the results, Table 3 displays the effect of five wheat cultivars on the pasting temperature (°C). Maaroof cultivar C_4 recorded the maximum among all cultivars, which was 68.25°C, followed by Alla C_1, Hasad C_2, and Adana (control) C_5 with (67.5°C, 66.75°C, and 65.92°C) respectively. Furthermore, Charmo C_3 had the lowest pasting temperature (gelatinization temperature), which was 63°C. Throughout all the five genotypes and two sowing date interactions, the pasting temperature value varied significantly, in the range of 68.33°C–62.33°C from $C_1 \times S_2$ to Charmo on the same sowing at L_1. While, in the same Table for L2, shows that the late sowing S_2 value is 66.5°C, which is higher than the normal sowing S_1 of 61.9°C. Regarding the effect of C × S interaction on the pasting temperature PT, it ranged from 70.17°C for Charmo on the late sowing (C_3 S_2) to 54.67°C for the same cultivar on the normal sowing (C_3 S_1). For the combined analysis expression in Table (2), cultivars (C), sowing date (S), location (L), C x S interaction, C x L interaction, S x L interaction, and tri-interaction among C x S x L, wholly significant mean squares, indicating that their means are significantly different. In Table 7, the Maaroof cultivar (C_4) documented the highest pasting temperature, which was 67.08°C, and the lowest was recorded by the Charmo (C_3) cultivar, which was 62.71°C. The others were Adana (control) C_5 (66.33°C), Alla C_1 (65.58°C), and Hasad C_2 (64.50°C). The consequences showed that the wheat cultivars' average values at the late sowing S_2 (66.63°C) surpassed the normal sowing S_1 (63.85°C) significantly. According to the two locations, the mentioned value in the Qlyasan location L_1 was 66.28°C greater than in Halabja L_2, which was 64.20°C. The interactions between cultivars and sowing dates, C_4 x S_2 and Adana or (control) C_5, on the same sowing with 67.50°C gave the maximum, while C_3 x S_1 with 59.17°C gave the minimum. For the significant interaction locations and cultivars mentioned above, the average $C_4 \times L_1$ was 68.25°C, and the $C_2 \times L_2$ was 62.25°C. According to the interaction of S × L, the average of the $S_2 \times L_1$ is 66.77°C, which is the maximum and significantly varied, while the $S_1 \times L_2$ is 61.90°, which is the minimum. The tri-interaction among the cultivars, sowing date, and location ranged from C_3 S_2 L_2 with 70.17°C to the same cultivars on the normal sowing and same location with 54.67°C**.** According to our results, it could be concluded that Charmo cultivar C_3 required a maximum temperature for the beginning of gelatinization as compared to the other cultivars. The late sowings, S_2 and Qlyasan L_1, recorded the higher average. All two and three interactions have a substantial effect on this parameter.

Table 7. Effect of wheat cultivars, sowing dates, locations and their interaction on pasting temperature (ºC)

Locations (L)	Sowing date (S)	cultivars (C) Alla (C1)	Hasad (C2)	Charmo (C3)	Maaroof (C4)	Adana Control (C5)	S* L
Qlyasan L1	S1	66.67 d	66.83 cd	63.67 f	68.17 bc	63.67 f	65.80 b
	S2	68.33 b	66.67 d	62.33 fg	68.33 b	68.17 bc	66.77 a
Halabja L2	S1	62.17 gh	60.83 h	54.67 i	65.17 e	66.67 d	61.90 c
	S2	65.17 e	63.67 f	70.17 a	66.67 d	66.83 cd	66.50 a
L1		67.50 ab	66.75 bc	63.00 de	68.25 a	65.92 c	66.28 a
L2		63.67 d	62.25 e	62.42 e	65.92 c	66.75 bc	64.20 b
S1		64.42 cd	63.83 d	59.17 e	66.67 ab	65.17 c	63.85 b
S2		66.75 ab	65.17 c	66.25 b	67.50 a	67.50 a	66.63 a
C Mean		65.58 c	64.50 d	62.71 e	67.08 a	66.33 b	

LSD 0.05: C=0.6832, S=0.4321, L=0.3239, C*S=0.9662, C*L=0.9662, S*L=0.6111, C*S*L=1.3665

Water absorption (WA) (%):

The mean square of cultivars (C) was highly significant at L1, while sowing date and CxS interaction were highly significant and significant, respectively at L_2, demonstrating that it varied among their mean Table 2. Table 3 shows differences were noticed between cultivars (C) due to the percentage of water absorption character. The Charmo cultivar C_3 had the greatest percentage of 83.85%, while Alla C_1 had the smallest of 78.917%. The others cultivars ranged from Adana (control) C_5 of 81.16%, Hasad C_2 of 79.84%, and Maaroof C_4 of 79.56%. The results in Table 3 illustrate a non-significant differences between two sowing dates, as well as the interaction between C × S at L_1. With reference to L_2 the first sowing S_1 was 80.66% more than the second sowing, S_2, which was 76.8 and the interaction of C × S affected this parameter significantly, which varied from 84.1% to 74.9% for C_2 S_1 and C_1 S_2, respectively. From the combined analysis expression in Table (2), C, S, C x S, C x L, S x L interactions, and interactions among C x S x L were declared highly significant mean squares, while location (L) was significant. As indicated in Table 8 the Charmo cultivar C_3 had the highest mean value of 82.58%, while the Marroof cultivar C_4 had the lowest of 78.28%. Moreover, the three tested cultivars which were at par with each other were Hasad C_2 with 79.85%, Adana (control) C_5 with 79.08% and C_1 with 78.82%. These results are in accordance with those of (32). The maximum amount of water, expressed as a percentage of flour weight, that will produce a high yield of bread during the baking process is called optimal absorption (26). Normal sowing S_1 had a higher percentage of significant changes (80.35%) than late sowing S_2 (79.09%). That is in line with (36). In terms of locations (L), the average in Qlyasan L_1 was 80.67% higher than in Halabja L_2, which was 78.77%. The reports by (24). In terms of cultivar-sowing-date interactions, C_3 x S_1 yielded the highest of 82.78%, while C_1 x S_2 yielded the lowest of 76.55%. C_3 ×L_1 had the highest significant average, while C_4 × L_2 had the lowest, with 83.85% and 76.98%, respectively. These results corroborated the findings by (29) and (31), who illustrated a significant difference due to the C-S interaction, whereas there is no corroboration in the study by (48). according to the cultivar x location interactions, the Charmo cultivar C_3 had the highest mean value of 83.85, while the Marroof cultivar C_4 had the lowest of 76.98%. Our investigation of CL interaction significantly affected water absorption, the same result found by (39) and (24), while (32) revealed different results of the CL interaction.

Table 8. Effect of wheat cultivars, locations, sowing dates, and their interaction on water absorption (%)

Locations (L)	Sowing date (S)	cultivars (C) Alla (C1)	Hasad (C2)	Charmo (C3)	Maaroof (C4)	Adana Control (C5)	S* L
Qlyasan	S1	79.63 efg	79.15 fg	82.30 bcd	78.53 fg	80.60 def	80.04 b
L1	S2	78.20 gh	80.53 def	85.40 a	80.60 def	81.73 cde	81.29 a
Halabja	S1	82.53 bcd	84.10 ab	83.27 abc	75.70 ij	77.70 ghi	80.66 ab
L2	S2	74.90 j	75.60 ij	79.33 fg	78.27 gh	76.30 hij	76.88 c
L1		78.92 c	79.84 bc	83.85 a	79.57 c	81.17 b	80.67 a
L2		78.72 c	79.85 bc	81.30 b	76.98 d	77.00 d	78.77 b
S1		81.08 b	81.63 ab	82.78 a	77.12 d	79.15 c	80.35 a
S2		76.55 d	78.07 cd	82.37 ab	79.43 c	(9.02 c	79.09 b
C Mean		78.82 bc	79.85 b	82.58 a	78.28 c	79.08 bc	

LSD 0.05: C=1.0776, S=0.6815, L=1.8924, C*S=1.5239 C*L=1.5239, S*L=0.9638, C*S*L=2.1552

The result of interactions between sowing dates and locations shows a significantly varied pattern. The S_2 x L_1 had a maximum of 81.29%, while the average of S_2 x L_2 had a minimum of 76.88%. There were significant differences among the tri-interaction cultivars, locations, and sowing dates, which ranged from C_3 × S2 × L_1 with 85.4%, to Alla on the same sowing date and Halabja location with 74.90%. _It concluded that the results of this study demonstrate that the genotypes, the environment (sowing date and location), and their interactions have a high impact on water absorption WA%. The Charmo C_3 cultivar is superior to other cultivars for this trait. Normal sowing S_1 and Qlyasan L_1 are the most appropriate environments to obtain a higher percentage of water absorption. All (di and tri) interactions have a significant effect on the mentioned trait.

Loaf volume (LV) (cm^3): Loaf volume is considered significant evidence for explaining bread characteristics by Rosell *et al*. (43). It is useful because it provides a quantitative measure of bread achievement. The mean square of cultivars (C) and sowing dates (S), as well as their interaction C × S, were highly significant, significant, and significant, respectively at Halabja location L_2, while only CxS was significant in Qlyasan location L1 (Table 2). According to Table 3, the C5 × S2 has the greatest value, with 168 cm3, compared to the others, and the C2 × S1 with 122.3 cm3, has the lowest value at L1. At L2 as shown in the same Table, the Maaroof cultivar C_4 and Adana (control) cultivar C_5 (151 and 120 cm3) obtained the greatest and fewest, respectively, while the others were Hasad C_2 (136 cm^3), Alla C_1 (127), and Charmo C_3 (121). The late planting S_2 (134.3 cm^3) substantially exceeded the normal sowing S_1 (127.7 cm^3). In terms of the interactions between C × S, exhibited that the highest value of this parameter is $C_4 \times S_1$ (154 cm^3), while the lowest are $C_1 \times S_1$ and $C_5 \times S_1$ (115 cm^3). These differences in loaf volume could be due to gluten variation. Gluten reductions by fibers have a really weak effect on dough blends (20). For the combined analysis, mean squares attributable to cultivars (C), sowing dates (S), location (L), and interactions of (C x S, C × L and C × S × L) showed very significant changes in their means (Table 2). As revealed in Table 9, it was found that the loaf volume (LV) cultivars' mean varied from the greatest for Maaroof C_4 (142.4 cm^3), followed by Hasad C_2 (137.7 cm^3), and the last three cultivars, Alla C_1 (134.8 cm3), Adana (control) C_5 (134.6 cm^3), and Charmo C_3 (134.3 cm^3), were in par with each other's. This result corroborated the study by (23). These differences in loaf volume could be due to gluten variation. Gluten reductions by fibers have a really weak effect on dough blends (20). In terms of sowing date, the late sowing S_2 (140.4 cm^3) considerably surpassed the normal sowing S_1 (133.1 $cm^{3)}$. There was significant variation between the two locations, which is consistent with the findings of (22). Research by Laidig *et al* (30) indicated that genotype was the most important factor that determined the loaf volume difference. On the other hand, Järvan *et al* (27) reported that loaf volume varied depending on the sowing and location. According to location, the average value in Qlyasan L_1 was (142.5 cm^3) higher than in Halabja L_2 (131.0 cm^3). This finding was consistent with what was found by (33). According to the C × S interaction, the $C_5 \times C_2$ has the largest, while the same cultivar on normal sowing has the smallest (146.5 cm^3 and 122.7 cm^3, respectively). The C × L interaction ranges from $C_4 \times L_2$ (151.0 cm^3) to Adana (120.0 cm^3) at the same location. Nevertheless, there was no significant difference in S × L interaction. The result of significant C × S effects was supported by (33). (51) discovered the same to our result of C × L interaction. The data of tri-interactions among C × S × L exhibited the $C_5 \times S_2 \times L_1$ having the maximum value of loaf volume (168.0 cm^3), while the $C_5 \times S_1 \times L_2$ Adana (control) and also Alla on the same sowing and location had the minimum value (115.0 cm3). From the overall discussion of the results of the experiment, it was concluded that Maaroof C_4 had the higher amount. Late sowing S_2 and Qlyasan L_1 loaf volume were consistently higher than S_1 and L_2. All di and tri-interactions have significant effects on this trait except the S × L interaction.

Table 9. Effect of wheat cultivars, sowing dates, locations, and their interaction on loaf volume (cm^3)

Locations (L)	Sowing date (S)	cultivars (C) Alla (C1)	Hasad (C2)	Charmo (C3)	Maaroof (C4)	Adana Control (C5)	S* L
Qlyasan L1	S1	147.3 c	122.3 hi	154.0 b	138.7 de	130.3 fg	138.5
	S2	138.0 de	156.3 b	141.3 d	129.0 g	168.0 a	146.5
Halabja L:2	S1	115.0 j	137.3 de	117.0 ij	154.0 b	115.0 j	127.7
	S2	139.0 de	134.7 ef	125.0 gh	148.0 c	125.0 gh	134.3
L1		142.7 b	139.3 bc	147.7 a	133.8 d	149.2 a	142.5 a
L2		127.0 e	136.0 cd	121.0 f	151.0 a	120.0 f	131.0 b
S1		131.2 d	129.8 d	135.5 bc	146.3 a	122.7 e	133.1 b
S2		138.5 b	145.5 a	133.2 cd	138.5 b	146.5 a	140.4 a
C Mean		134.8 c	137.7 b	134.3 c	142.4 a	134.6 c	

LSD 0.05: C=2.6852, S=1.6983, L=2.8823, C*S=3.7975, C*L=3.7975, S*L=N.S., C*S*L=5.3705

Conclusion

According to combined analysis, the cultivars mean significantly differentiated in quality traits were the cultivar Charmo had higher values for grain protein content and water absorption traits, while Adana cultivar as a control for, gluten index and falling number, whiles Maaroof for the remained traits (pasting temperature, and loaf volume), of this study indicate that even in different environmental conditions, sowing bread wheat lately is an accept option for maximizing grain protein content, gluten index ratio, pasting temperature, and loaf volume, while, optimum sowing was increasing falling number and water absorption traits, regardless of cultivar or location. Wheat grown in Qlyasan location appeared to have more protein content, falling number, water absorption, pasting temperature, and loaf volume. While Halabja location to have stronger gluten quality (GI). The di-interactions viz. CS, CL, and SL and tri-interaction CSL played a significant important role in changing or modifying the values, up or down of the quality traits. Regarding to quality criteria for grain, dough and bread, the tri-interaction C_3 S_2 L_1 had the highest protein content while, C_4 S_1 L_2 obtained good quality criteria vis. gluten index, falling number, water absorption, pasting temperature, and loaf volume.

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