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Evaluation of Fifty New Bread Wheat Genotypes Under Duhok Rainfall Conditions

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Abstract

This field experiment assessed the performance of 50 newly introduced bread wheat genotypes acquired from the ICARDA agency. The genotypes were sown under rainfall conditions at two separate locations at the end of November 2022. The planting was organized in lines spanning three meters in length and 0.5-meters apart. The study employed a randomized complete block design. The findings showed significant variations among the bread wheat genotypes for all evaluated traits, except for flag leaf area and spike length, across both locations. This pattern persisted in the interaction between genotypes and locations with the Zenawa location outperforming Semel. Subsequently, to advance the program, ten superior genotypes (G1, G6, G7, G12, G13, G25, G27, G37, G38, and G40) were selected based on their high yield and favorable growth traits. These were subject to further investigation in three separate locations during the winter season of 2023-2024. This research initiative received support from the MCC and ZSVP organizations, underscoring the collaborative efforts driving the investigation. This study offers valuable insights into the adaptability and productivity of recently introduced bread wheat genotypes, with implications for future breeding programs and agricultural practices to enhance wheat cultivation in Iraq under diverse environmental conditions.

Keywords: Wheat, Genotypes, Rainfall, Locations.

تقييم خمسون تركيبا وراثيا من حنطة الخبز تحت الظروف المطرية لمحافظة دهوك

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الخلاصة

أجريت هذه الدراسة لتقييم أداء خمسين نمطا وراثيا من حنطة الخبز تم إدخالها مؤخرا والحصول عليها من مؤسسة إيكاردا، زرعت انماط الحنطة في ظل الظروف الديمية في موقعين مختلفين، تم عملية الزراعة في نهاية شهر تشرين الثاني من 2022 تم تنظيم الزراعة في خطوط امتدت بطول ثلاثة أمتار مع وجود مسافة 0.5 متر بين الخطوط باستخدام تصميم القطاعات العشوائية الكاملة وبثلاث مكررات، تضمنت الدراسة مائة وخمسين وحدة تجريبية، اظهرت نتائج الدراسة عن اختلافات كبيرة بين الأنماط الوراثية لحنطة الخبز لجميع الصفات المدروسة التي تم تقييمها باستثناء المساحة الورقية وطول السنبلة في كلا الموقعين. وتبين هذا الاختلاف ايضا بين الأنماط الوراثية والمواقع بحيث تفوق موقع زيناوا على موقع سيميل في معظم الصفات، تم اختيار عشرة أنماط وراثية متفوقة : G1 وG6 و G7 و G12 و G13 و G25 و G27 و G37 و G38 و G40 بناء على إنتاجيتها العالية وصفات النمو وستخضع هذه الأنماط الوراثية المختارة لمزيد من الدراسات خلال موسم الشتاء 2023-2024في ثلاثة مواقع مختلفة لتثبيت تفوقها في الانتاج وتسجيلها ومن الجدير بالذكر أن المبادرة البحثية قد تلقت دعما من منظمتي MCC وZSVP، مما يؤكد الجهود التعاونية التي تدفع مسيرة العلم إلى الأمام وتساهم هذه الدراسة برؤى قيمة حول القدرة على التكيف والإنتاجية للأنماط الوراثية لحنطة الخبز التي تم إدخالها مؤخرا مع ما يترتب على ذلك من آثار على برامج التربية المستقبلية والممارسات الزراعية التي تهدف إلى تعزيز زراعة الحنطة في العراق و في ظروف بيئية متنوعة.

كلمات مفتاحية: الحنطة، تراكيب وراثية، ديمي، مواقع.

Introduction

Bread wheat, classified as an annual plant within the Gramineae family, has a prominent position as a central staple food globally (11), and is a primary crop in Iraq and the Kurdistan Region (13). The increasing demand for wheat due to population growth (7) underscore the importance of introducing advanced varieties with superior traits, particularly in terms of yield and its components. A wheat genotype's high yield potential indicates its efficient utilization of natural resources, producing optimal yields in specific environments. Additionally, (7) argued that the true value of a genotype extends beyond individual trait productivity to its ability to possess these traits at a high level in diverse locations, especially in unfavorable agroecological conditions, depending on genotype adaptability. The selection of wheat genotypes is based on either optimal or less favorable environmental conditions, to achieve wide or narrow adaptability, as suggested by (13).

Moreover, (4 and 7) point out that environmental conditions of total precipitation, drought, and temperature fluctuations, significantly influence fertility efficiency, assimilation acceptor capacity, grain filling, and assimilate translocation from stalks and leaves to grains. Several researchers, including (1, 9 and 13), highlight that those environmental factors, particularly drought stress, can occur at various stages of the growing season, but its impact on yield reduction is most pronounced when it transpires after anthesis.

This study evaluated the impact of 50 diverse wheat genotypes across two distinct agro-ecological locations, with a primary focus on quantifying yield and its component traits. By subjecting these genotypes to varying environmental conditions, the research aimed to delineate their adaptability and stability. The paramount objective was to discern genotypes exhibiting consistent performance across heterogeneous environments. This investigation contributes to enhancing the understanding of genotype-environment interactions and facilitating the identification of wheat varieties resilient to diverse ecological challenges, thereby contributing to sustainable and productive agricultural practices.

Materials and Methods

Fifty new genotypes of bread wheat Triticum aestivum L., were procured from ICARDA (International Center for Agricultural Research in the Dry Areas), as listed in Table 1. They were sown in two different locations, i.e., at the College of Agricultural Engineering Sciences, Duhok University (Semel; 36°51'30"N 42°51'0.35"E) 15 km west of Duhok center, and the Zenawa region (36°39'23.9"N 43°28'48.9"E), 85 km east of Duhok.

Table 1: Wheat genotypes used in the study.

GENOTYPE (G)	CROSS	SOURCE
1	QAFEDU	ISBW14T-205 -0SD-010KU-3KUL-0KUL
2	ATLAS	
3	ACHTAR/5/SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/TEVEE'S'/BOBWHITE #1	ISBW17-TR-0068-0TR-0TR-5MR-0MR
4	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/PFAU/MILAN/5/KEKEBA	ISBW17-TR-0776-0TR-0TR-2MR-0MR
5	KHIDER/4/P1.861/RDWG//ESWYT99#18/ARRIHANE/3/PFAU/MILAN	ISBW17-TR-0020-0TR-0TR-3MR-0MR
6	PFAU/MILAN/3/BABAX/LR42//BABAX*2/4/NIINI #1/5/DANDA	ISBW17-TR-1043-0TR-0TR-5MR-0MR
7	MILAN/KAUZ//PRINIA/3/BAV92/4/BAVIS/6/PREMIO/5/CROC_1/AE.SQUA RROSA (205)//BORL95/3/PRL/SARA//TSI/VEE#5/4/FRET2	ISBW17-TR-1051-0TR-0TR-7MR-0MR

8	SERI.1B//KAUZ/HEVO/3/AMAD/4/ESDA/SHWA//BCN/5/HONQOL O	ISBW17-TR-0746-0TR-0TR-6MR-0MR
9	SOKOLL//NADA-1/AVYR 5+18/5/MILAN/KAUZ//PRINIA/3/BAV92/4/BAVIS	ISBW17-TR-0351-0TR-0TR-1MR-0MR
10	CHAM-8/6/HUBARA-1/5/CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/VEE#7/BOW/4/PASTOR	ISBW17-TR-0018-0TR-0TR-4MR-0MR
11	02W50807_1/4/PFAU/SERI.1B//AMAD/3/WAXWING/5/BECARD//KI RITATI/ 2*TRCH/3/BECARD/4/NEJMAH-6/PAVON SR 24+ SR 26+SR 31	ISBW17-TR-0066-0TR-0TR-7MR-0MR
12	DANDA/4/P1.861/RDWG//ESWYT99#18/ARRIHANE/3/PFAU/MILA N	ISBW17-TR-0028-0TR-0TR-1MR-0MR
13	KHIDER/5/NEJMAH-6/PAVON SR 24+ SR 26+SR 31/4/ATTILA/TNMU//TNMU/3/SR 33+SR 45 #36	ISBW17-TR-0019-0TR-0TR-7MR-0MR
14	FLAG-5/SR 50+SR 45 # 10//KACHU #1/3/GUNA /AVYR 5+18//NEJMAH-6/PAVON SR 24+ SR 26+SR 32	ISBW17-TR-0380-0TR-0TR-9MR-0MR
15	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/TEVEE'S'/BOBWHITE #1/7/PBW343*2/KUKUNA//PBW343*2/KUKUNA/6/WBLL1*2/4/SNI /TRAP# 1/3/KAUZ*2/TRAP//KAUZ/5/KACHU	ISBW17-TR-0774-0TR-0TR-3MR-0MR
16	RHINO 1A.1D 5+10-4/TILHI//NEJMAH-14/4/SUDAN#3/SHUHA-6//FLAG- 5/3/PFAU/MILAN	SBW17-MR-677-0KUL 4MR-0MR
17	ATTILA*2/PBW65//PFAU/MILAN/3/HUBARA-3*2/SHUHA-4	ISBW17-MR-18-0KUL-8MR-0MR
18	Misr-1/Angi-1	ISBW17-MR-52-0KUL-3MR-0MR
19	TNMU/MUNIA//MIRIAM 41/7/PFAU/MILAN/5/CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/VEE#7/BOW/4/PASTOR/6/2*BAVIS #1	ISBW16MR-199-040MR-1MR-0MR
20	QUAIU*2/KINDE/4/PFAU/MILAN/3/BABAX/LR42//BABAX	ISBW16MR-70-040MR-6MR-0MR
21	Misr-1//KACHU*2/BECARD	ISBW17-MR-54-040MR-6MR-0MR
22	PASTOR/WBLL1/4/MUTUS//KIRITATI/2*TRCH/3/WHEAR/KRONS TAD F2004/7/SHARP/3/PRL/SARA//TSI/VEE#5/5/VEE/LIRA//BOW/3/BC N/4/KA UZ/6/NEJMAH-27	ISBW17-MR-739-040MR-5MR-0MR
23	Misr-1/6/SERI.1B//KAUZ/HEVO/3/AMAD/4/PYN/BAU//MILAN/5/OPATA /RAYON/ /KAUZ	ISBW17-MR-56-040MR-1MR-0MR
24	ATTILA/TNMU//TNMU/6/TDICOCCUM1/CH1//ICAMORTA0469/3/I CAMORT A0459//CANDOCROSSH25/BLK204144/4/MRF1/STJ2//BCRCH1/5/F 413/3/ ARTHUR71/LAHN//BLK2/LAHN/4/QUARMAL/7/MILAN/KAUZ//P RINIA/3/BA V92/4/BAVIS/8/KATILA-1/3/SNI/HD2281//STAR/4/ICARDA-SRRL-2	ISBW17S-TR-0713-0TR-0TR-4MR-0MR
25	UTIQUE 96/FLAG-1//SR 22/CO 1213/7/SERI.1B//KAUZ/HEVO/3/AMAD/4/PYN/BAU//MILAN/5/OP ATA/RAY ON//KAUZ/6/SR 50+SR 45 # 1/8/TERBOL/9/DEBEIRA//MILAN/PASTOR/4/URES/BOW//OPATA/ 3/HD22 06/HORK'S'	ISBW17S-TR-0125-0TR-0TR-4MR-0MR
26	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/KAUZ/FLORKWA-1/5/CHAM-8/8/WHEAR/KUKUNA/3/C80.1/3*BATAVIA//2*WBLL1/4/PAURAQ UE #1/5/WHEAR/KUKUNA/3/C80.1/3*BATAVIA//2*WBLL1/6/INQALA B	ISBW17S-TR-0647-0TR-0TR-3MR-0MR

	91/FLAG-2//SR 22/CO 1213/7/PBW343*2/KUKUNA//PBW343*2/KUKUNA/6/WBLL1*2/4/SNI/TRA P#1/3/KAUZ*2/TRAP//KAUZ/5/KACHU	
27	QAFZAH-19//VEE7/KAUZ/3/KEKEBA/5/SERI.1B//KAUZ/HEVO/3/AMAD/4/KAUZ/GY S//KAUZ	ISBW17S-TR-0598-0TR-0TR-7MR-0MR
28	ATTILA*2/RAYON//CATBIRD-1/3/AVYR 5+18/4/MILAN/MUNIA//SR 33+SR 45 #23/5/PASTOR-6/7/CHAM-8/6/HUBARA-1/5/CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/VEE#7/BOW/4/PASTOR	ISBW17S-TR-0482-0TR-0TR-1MR-0MR
29	COPIO*2/3/KINGBIRD #1//INQALAB 91*2/TUKURU/4/ESKINA-8/BONITO-36	ISBWS18-TR-1228-0TR-0TR-6TR-0TR
30	F12.71/SKA//FKG15/3/F483/4/CTK/VEE/5/SHARK/F4105W2.1/6/SORA/AE .SQUARROSA (208)/7/MELON//FILIN/MILAN/3/FILIN/4/TRCH/SRTU//KACHU	ISBW17-MR-802-0MR-7MR-0MR
31	DANPHE #1/2*SUP152/4/MILAN/KAUZ//PRINIA/3/BABAX/5/QUAIU*2/DANPHE	ISBW17-MR-393-0MR-6MR-0MR
32	DOY1/AE.SQUARROSA (1026)/5/SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/ANGI-26/6/PFAU/MILAN//ABIER-2/3/SHUHA-3//TURACO/CHIL	ISBW17-MR-187-0MR-5MR
33	QUAIU*2/KINDE/4/PFAU/MILAN/3/BABAX/LR42//BABAX/6/CROC_1/AE.S QUARROSA (205)//BORL95/3/PRL/SARA//TSI/VEE#5/4/FRET2/5/WHEAR/SOKOLL	ISBW17-MR-367-0MR-4MR
34	YAV_2/TEZ//AE.SQUARROSA (895)/6/BOUSHODA-1/5/CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/VEE#7/BOW/4/PASTOR/7/TRCH/SRTU//KACHU/3/KINGBI RD #1	ISBW17-MR-175-0MR-3MR
35	BABAX/LR42//BABAX/3/BABAX/LR42//BABAX/5/OASIS/SKAUZ//4*BCN/3/PASTOR/4/KAUZ*2/YACO//KAUZ/6/TRCH/SRTU//KACHU*2/3/KINGBIRD #1/WEAVER/TSC//WEAVER/3/WEAVER/4/WAXWING/5/MILAN/SHA7//P OTAM*3KS811261-5	ISBW19-MR-0271-040MR-5MR-0MR
36	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/TEVEE'S'/BOBWHITE #1/7/PBW343*2/KUKUNA//PBW343*2/KUKUNA/6/WBLL1*2/4/SNI/TRAP# 1/3/KAUZ*2/TRAP//KAUZ/5/KACHU/8/WATAN-7/SEKHRAH-2/7/PVN//KAUZ/PVN/4/CROC1/AE.SQUARROSSA(205)//KAUZ/3/ATTILA/ 5/SR 33+SR 45 #36/6/MISIR-1/9/SAUAL/3/SW89.3064//CMH82.17/SERI/4/SAUAL/5/PBW343*2/KUKUN A*2//FRTL/PIFED/6/SAUAL/KRONSTAD F2004	ISBWS18-TR-1322-0TR-040MR-5MR-0MR
37	QAFZAH-18//P1.861/RDWG/4/HUIRI√IS #1*2/MURGA/3/TACUPETO F2001/BRAMBLING*2//KACHU	ISBWS18-TR-0057-0TR-0TR-8TR-0TR
38	QAFZAH-18//P1.861/RDWG/3/BECARD/AKURI//WAXBI	ISBWS18-TR-0058-0TR-0TR-5TR-0TR
39	QAFZAH-19//VEE7/Kauz/6/KACHU #1/YUNMAI 47//KACHU/5/SAUAL/3/C80.1/3*BATA√IA//2*WBLL1/4/SITE/MO//PASTOR/ 3/TILHI	ISBWS18-TR-0066-0TR-0TR-9TR-0TR
40	KAUZ//ALTAR 84/AOS 3/KAUZ/3/ATENA-1/4/FLAG-7/5/KFA/2*KACHU/3/KINGBIRD #1//INQALAB 91*2/TUKURU/4/KFA/2*KACHU	ISBWS18-TR-0188-0TR-0TR-6TR-0TR
41	KAUZ'S'/SERI//PFAU/MILAN/3/KFA/2*KACHU*2//WAXBI	ISBWS18-TR-0289-0TR-0TR-

		9TR-0TR
42	KACHU #1//HUW 234/REBWAH-19	ISBWS18-TR-0454-0TR-0TR-3TR-0TR
43	KACHU/SUP152/4/PFAU/MILAN//ABIER-2/3/SHUHA-3//TURACO/CHIL	ISBWS18-TR-0465-0TR-0TR-4TR-0TR
44	SAUAL/YANAC//SAUAL/3/BECARD/QUAIU #1/4/THELIN/WAXWING//ATTILA*2/PASTOR/3/INQALAB91*2/TUKURU 9Y-0B	ISBWS18-TR-0531-0TR-0TR-1TR-0TR
45	MUTUS*2/TECUE #1/3/KINGBIRD #1//INQALAB 91*2/TUKURU/4/THELIN/WAXWING//ATTILA*2/PASTOR/3/INQALAB91*2/TUKURU 9Y-0B	ISBWS18-TR-0591-0TR-0TR-1TR-0TR
46	KFA/2*KACHU/3/PBW343*2/KUKUNA*2//FRTL/PIFED/4/KFA/2*KACHU/5/SERI.1B*2/3/KAUZ*2/BOW//KAUZ*2/4/MNCH/3*BCN	ISBWS18-TR-0747-0TR-0TR-8TR-0TR
47	KACHU/SAUAL*2//COPIO/5/KATILA-/3/SNI/HD2281//STAR/4/ICARDASRRL-2	ISBWS18-TR-0803-0TR-0TR-1TR-0TR
48	WAXBI*2/COPIO/5/KATILA-1/3/SNI/HD2281//STAR/4/ICARDA-SRRL-2	ISBWS18-TR-0858-0TR-0TR-5TR-0TR
49	ALTAR 84/AE.SQUARROSA (JBANGOR)//ESDA/3/HEILO/5/CNO79//PF70354/MUS/3/PASTOR/4/BABAX/7/PRL/2*PASTOR/4/CHOIX/STAR/3/HE1/3*CNO79//2*SERI/5/PA√ON SR 24+ SR 31+SR 50/6/05W90045 U.S.A.-08CJ/PA√ON SR 24+ SR 26+SR 31/8/PBW343/ETBW 4921//QAMAR-6/9/KACHU #1/YUNMAI 47//KACHU/5/SAUAL/3/C80.1/3*BATA√IA//2*WBLL1/4/SITE/MO//PASTOR/3/TILHI/6/KACHU #1/KIRITATI//KACHU	ISBWS18-TR-0919-0TR-0TR-5TR-0TR
50	Local check	Cihan-3 variety

The sowing process commenced on November 25, 2022, coinciding with the onset of rainy conditions which are crucial for optimal wheat growth. Table 2 shows the average temperature, the amounts of rainfall (mm), and its distribution through the growing season in both locations.

Table 2: Monthly rainfall and temperatures for the Zenawa and Semel locations.

Month	Rainfall (mm)		Avg. temperature (^{0}C)	
	Zenawa	Semel	Zenawa	Semel
Oct-22	5	0	31.0	34.8
Nov -22	70	188.3	21.2	29.62
Dec-22	9	3.2	19.2	22.10
Jan-23	74	45	12.2	16.75
Feb-23	75	62.4	9.30	14.58
March-23	86	66.9	10.31	12.33
Apr-23	114	60.3	12.9	10.33
May-23	15	17.5	15.40	17.33
Total	448	443.6		

* College of Agricultural Engineering Sciences and Shekhan meteorological stations.

Soil preparation involved double plowing with a moldboard plow in a perpendicular manner, followed by smoothing, leveling, and planning operations specific to each location. Sowing was done in 3-meter-long lines and 0.50 meters apart. To enrich the soil, a recommended compound fertilizer (NPK 20:20:20) was applied before sowing at 140 kg ha^{-1}. Further fertilization involved the addition of urea fertilizer (N 46%) at a rate of 160 kg ha^{-1} in two doses at the tillering stage and after flowering (13).

The 150 experimental units (three replications and fifty genotypes) adhered to a randomized complete block design, with each featuring one line of each genotype. For weed control, the herbicides Topic for narrow-leaved and Granstar for bread-leavened, were applied at the 2-3 leaf stage of weeds, adhering to scientifically recommended dosages (12).

Data collection involved various parameters important for assessing wheat performance, including plant height (PH, cm), heading date, maturity date, leaf area (SPAD), spike length (cm), 1000-grain weight (g), and total grain yield (kg. ha^{-1}). The statistical analyses were conducted using Microsoft Office Excel, Statistical Analysis System (SAS), and Minitab. Duncan's multiple range test was applied to compare the means of the genotypes. Additionally, Cihan-3 variety (G50) was included as a check variety. Analyses of variance were undertaken for the genotypes at each location, and a combined analysis was performed for both locations and wheat genotypes.

Results and Discussion

Table 3 shows the analysis of variance on the bread wheat genotypes cultivated in Semel. There is a statistically significant mean square for the genotypes at a 1% probability level across all examined traits, except leaf area and spike length, which did not attain statistical significance. This suggests substantial variation among the genotypes for most of the studied morphological characteristics, as also noted by various other researchers (9, 12 and 13).

Table 3: Analysis of variance of the bread wheat genotypes for the studied traits in the Semel location.

SOV	df	MS						
		Traits						
		Plant height (cm)	Heading date (days)	Maturity date (days)	Leaf area (cm^2)	Spike length (cm)	1000-grain weight (g)	Total grain yield (kg. ha^{-1})
Rep.	2	26.1	0.09	7.29	552.25	1.44	6.86	88.14961
Genotypes	49	** 107.52	** 15.50	** 23.16	156.99	1.46	** 29.72	** 1435.96558
Error	49	3.39	0.25	2.18	98.96	1.29	5.48	646.3954
Total	99							

** Significance at 0.01 probability.

Table 4 shows the variation in plant height among the studied wheat genotypes. G46 exhibited the tallest plants at 103 cm, followed closely by G45 and G49 at respective heights of 103 cm and 101 cm. In contrast, G3 had the shortest stature at 71.5 cm, revealing significant diversity among the genotypes employed in this investigation. The days-to-heading also showcased considerable variability, with G13, G14, G19, G20, G29, G38, G39, G42, and G43 demonstrating the shortest duration at 127 days. Conversely, G8, G17, G23, G27, G31, and G33 required 134 days, constituting the longest duration for this trait, marking the 5% early heading threshold.

For days to maturity, G4 emerged as the earliest genotype, maturing in 160.5 days, closely trailed by G26 and G37 requiring 161 days. In comparison to the local variety, these genotypes exhibited early maturation percentages of 6% and 5%, respectively. Flag leaf area exhibited variations, ranging from 24.3 to 57.10 cm^2. G1 demonstrated the largest flag leaf area at 57.10 cm2, followed by G3 and G27 with values of 56.8 and 57.7 cm^2, respectively, signifying a 39% increase compared to the local variety. This increase positively correlated with enhanced yield and some of its components.

Spike length (SL) showed noteworthy differences among genotypes, with G18 recording the longest at 12.5 cm, followed by G25 and G32 at 12 cm. This characteristic markedly influenced yields in G25 and G32, at 6160.5 and 5083.5 kg. ha^{-1}, respectively while its impact was less evident in other genotypes. In terms of 1000-grain weight (1000-GW), G26 exhibited the highest value at 42.25g, followed by G42, G39, and G37 with respective weights of 41.75, 40.85, and 40.14g. The influence of this trait on yield was particularly pronounced in these genotypes.

Considering total grain yield, G38 emerged as the highest-yielding genotype at 7389.5 kg. ha^{-1}, succeeded by G37, G33, and G36 with yields of 6859.5, 6594.5, and 6316.5 kg. ha^{-1}, respectively. Consequently, these genotypes stand out as superior among the fifty evaluated, warranting recommendations for cultivation in this specific region. These findings align with (2, 9 and 12).

Table 4: Mean performance of the bread wheat genotypes for the studied traits in the Semel area.

Genotypes (G)	Plant height (cm)	Heading days	Days to maturity	Flag leaf area (cm^2)	Spike length (cm)	1000-grain weight (g)	Total grain yield (kg. ha^{-1})
1	72.5 qr	132.5 def	162 i-k	57.1 a	11 a-c	35.1 d-m	5623 a-g
2	75 p-r	133 cde	165.5 f-i	24.3 e	10.5 a-c	40.7 a-d	4739 c-i
3	71.5 r	128 hi	167 d-h	41 a-e	9.5 bc	30.65 j-q	5557 a-g
4	81.5 h-l	129 gh	160.5 k	32.7 a-e	10 a-c	33.6 f-o	4765.5 c-i
5	84 g-j	135 b	170.5 a-d	40 a-e	10.5 a-c	32.55 h-p	4688.5 c-i
6	93 bcd	132.5 def	167 d-h	34.25 a-e	11 a-c	34.95 e-m	4953 b-i
7	91 c-e	132.5 def	168.5 a-f	31.55 b-e	10 a-c	34.6 e-n	4093 f-i
8	84.5 g-i	134 bc	171.5 ab	48.25 a-e	9.5 bc	36.2 b-k	4760 c-i
9	91.5 b-e	127 i	167.5 c-h	24.35 e	11.5 a-c	33.4 g-p	6262.5 a-e
10	83 h-k	129.5 g	167.5 c-h	38.45 a-e	12 ab	38.8 a-g	6290.5 a-d
11	79 k-n	131.5 f	164.5 g-j	36.35 a-e	10 a-c	25.35 q	4352 d-i
12	89 d-f	133.5 cd	168 b-g	52.3 a-c	9.5 bc	41.05 a-c	6147 a-e
13	76.5 p-q	127 i	162.5 i-k	42.7 a-e	10 a-c	34.3 f-n	5900 a-f
14	86 f-h	127 i	162 i-k	27.15 de	10 a-c	37.5 a-h	5178 b-i
15	82.5 h-k	129.5 g	162.5 i-k	33.8 a-e	10.5 a-c	33.9 f-n	5173 b-i
16	82.5 h-k	133 cde	162.5 i-k	27.2 de	9.5 bc	32.8 h-p	5184 b-i
17	85 f-i	134 bc	164.5 g-j	36.8 a-e	9 c	31.35 j-p	4268.5 e-i
18	74 p-r	131.5 f	168.5 a-f	38.1 a-e	12.5 a	29.7 m-q	4351 d-i
19	85 f-i	127 i	162.5 i-k	27.95 c-e	10.5 a-c	35.75 c-L	4508 d-i
20	77.5 L-p	127 i	167 d-h	30.25 b-c	9.5 bc	35.75 c-L	5124.5 b-i
21	74.5 p-r	133 cde	169.5 a-e	25.3 de	10 a-c	28.15 o-q	3237 i
22	86 f-h	133 cde	169.5 a-e	26.2 de	9 c	35.75 c-L	3689.5 g-i
23	84.5 g-i	134 bc	168 b-g	40.3 a-e	11.5 a-c	32.7 h-p	4379.5 d-i
24	89 d-f	133 cde	170.5 a-d	28.75 c-e	10.5 a-c	30.3 L-q	4772 c-i

25	78 L-p	131.5 f	167 d-h	52.15 a-c	12 ab	37.5 a-h	6160.5 a-e
26	91.5 b-e	127 i	161 jk	28.8 c-e	10.5 a-c	42.35 a	5841 a-f
27	75 p-q	134 bc	172 a	56.7 a	11.5 a-c	36.75 a-j	4833 c-i
28	89 d-f	130 g	167.5 c-h	49.3 a-d	9.5 bc	33.45 g-p	4727.5 c-i
29	85 f-i	127 i	166.5 e-h	35.85 a-e	10.5 a-c	31.65 i-p	4508 d-i
30	83 h-k	132 ef	169.5 a-e	44.8 a-e	10.5 a-c	34.3 f-n	4884 b-i
31	81 j-m	134 bc	170.5 a-d	56.85 a	11 a-c	27.75 o-q	3470.5 hi
32	85 f-i	133 cde	169 a-f	37.55 a-e	12 ab	35.1 d-m	5083.5 b-i
33	88 e-g	134 bc	168.5 a-f	42.6 a-e	10 a-c	28.1 o-q	4134 f-i
34	88 e-g	132 ef	168.5 a-f	54.65 ab	12 ab	35.75 c-L	4552.5 d-i
35	93 bcd	133 cde	169 a-f	35.8 a-e	11.5 a-c	34.7 e-n	6594.5 a-c
36	95.5 b	132 ef	161.5 jk	41.6 a-e	10.5 a-c	32.55 h-p	6316.5 a-d
37	94.5 bc	129.5 g	161 jk	38.1 a-e	11 ab	40.15 a-e	6859.5 ab
38	83.5 L-j	127 i	162 i-j	38.85 a-e	10 a-c	33.15 g-p	7389.5 a
39	83 h-k	127 i	162.5 i-j	31.3 b-e	9.5 bc	40.85 a-c	5569.5 a-g
40	86 f-h	129 gh	162 i-j	27.75 c-e	10.5 a-c	39.3 a-f	4995.5 b-i
41	79 k-n	129 gh	164 h-k	38.1 a-e	10.5 a-c	35.8 c-L	4585.5 d-i
42	83 h-k	127 i	163 i-j	34.45 a-e	9.5 bc	41.75 ab	5080 b-i
43	84 g-j	127 i	167 d-h	38.9 a-e	9.5 bc	33.2 g-p	5672 a-g
44	85 f-i	129 gh	168 b-g	31.45 b-e	10.5 a-c	29.75 m-q	5247 b-h
45	103 a	132 ef	168.5 a-f	39.35 a-e	11 a-c	37.75 a-h	4720 c-i
46	104 a	136 bc	169.5 a-e	28.25 c-e	11.5 a-c	29.05 n-q	4952.5 b-i
47	77 n-o	132 ef	168.5 a-f	37.45 a-e	10 a-c	35.85 c-L	5266 b-h
48	89 d-f	127 i	161.5 jk	28.35 c-e	10.5 a-c	37.35 a-i	4926.5 b-i
49	101 a	129.5 g	161 jk	36.6 a-e	10.5 a-c	32.2 h-p	4500.5 d-i
50	80 k-m	136.5 a	171 a-c	34.85 a-e	9.5 bc	33.4 g-p	5945 a-f

*Means followed by different letters differ significantly from each other at 0.05 probability.

The results of the analysis of variance presented in Table 5 reveal a remarkably and statistically significant disparity among the genotypes for plant height, heading date, date of maturity, 1000-grain weight, and total grain yield in the Zenawa location. Similarly, there is statistical non-significance observed for leaf area and spike length. These findings align with the results obtained in the Semel location, as illustrated in Table 3 for the same traits, underscoring the substantial variation among the 50 bread wheat genotypes employed in this study. This is consistent with the findings of (10 and 11 and) who reported significant variations among genotypes when investigated across different locations or planting dates.

Table 5: Analysis of variance of the bread wheat genotypes for the studied traits in the Zenawa area.

SOV	df	MS						
		Traits						
		Plant height (cm)	Heading date	Maturity date	Leaf area (cm^2)	Spike length (cm)	1000-grain weight (g)	Total grain yield (kg. ha^{-1})
Rep.	2	108.16	2.56	30.25	559.36	0.04	41.26	1074332.3
Genotypes	49	* 99.08	** 14.42	** 40.56	196.89	1.68	** 24.62	** 5424889.9
Error	49	55.83	0.98	2.94	133.29	1.71	7.02	734686.4
Total	99							

** Significance at 0.01 and * 0.05 probability.

Table 6 illustrates the mean performance of seven distinct traits in the Zenawa location. Notably, G49 exhibited the highest plant height at 89.5 cm, followed closely by G36 and G37 at 89.5 cm and 78.0 cm, respectively, while G32 displayed the lowest at 61.5 cm. The mean values for days-to-heading ranged from 130 to 140 days post-sowing, with G9, G20, G26, and G43 emerging as the earliest genotypes, outpacing the check variety (G50). In terms of days to maturity, G42 and G37 proved to be early-maturing genotypes, requiring 166 and 166.5 days, respectively, while the check variety exhibited later maturity at 180.5 days. This indicates a highly significant variation among genotypes for days to heading and maturity, with all genotypes maturing earlier than the check variety.

For leaf area, G27 demonstrated the maximum at 61.5 cm2, outperforming the check variety by 54%, followed by G1 at 59.5 cm2, while G2 displayed the minimum leaf area of 23.8 cm2. For spike length, G1, G9, G18, and G25 recorded the highest values at 12.5 cm, while the lowest value, at 9 cm, was in G4. Regarding 1000-grain weight, G27 and G7 exhibited superior values at 52.15 g and 51.35 g, respectively, while G18, G24, and G16 displayed the lowest values of between 37.15 g to 37.9 g. Notably, 39 studied genotypes surpassed the check variety in this trait. Total grain yield ranged from 12,390.5 kg.ha^{-1} (G7) to 5,070 kg.ha^{-1} (G31), with 33 genotypes surpassing the check variety. These results highlight several promising genotypes for yield and various studied traits, aligning with the findings of (3, 7 and 13).

Table 6: Mean performance of the bread wheat genotypes for seven traits at the Zenawa location.

Genotypes (G)	Plant height (cm)	Days to heading (days)	Days to maturity (days)	Leaf area (cm^2)	Spike length (cm)	1000-grain weight (g)	Total grain yield (kg. ha^{-1})
1	83.5 a-d	135.5 e-h	170 g-k	59.5 ab	12.5 a	10799.5a-d	43.85 c-j
2	70.5 b-g	132 k-n	167.5 i-k	23.8 h	10 a-c	7912 g-q	45.7 b-g
3	77 a-g	132.5 j-m	172.5 e-h	41.15 a-h	10 a-c	10047 b-f	38 h-L
4	72.5 a-g	132.5 j-m	167.5 i-k	32.8 a-h	9 bc	8976.5 d-L	45.65 b-g
5	82.5 a-f	137.5 b-d	178 a-c	40.83 a-h	10.5 a-c	9708 b-h	43.7 c-k
6	75 a-g	136.5 c-g	177 a-d	35.83 a-h	11 a-c	9660 b-i	46.1 a-f
7	79.5 a-g	137 b-f	177 a-d	33.1 a-h	10.5 a-c	12390.5 a	51.35 ab
8	83 a-e	139 ab	179 ab	50.7 a-h	10 a-c	8074.5 f-q	40.35 d-L
9	70 b-g	130 n	169.5 g-k	24.83 gh	11.5 ab	8360.5 e-f	41.4 c-k
10	79.5 a-g	132.5 j-m	173 d-g	37.83 a-h	1.5 a	6507 p-s	47.05 a-c
11	69.5 b-g	132.5 j-m	168 i-k	36.75 a-h	11 a-c	9064 d-L	42.55 c-k
12	83.5 a-d	132.5 j-m	167.5 i-k	55.55 a-c	9.5 a-c	10216.5b-d	44.5 c-h
13	77 a-g	130.5 mn	168 i-k	42.63 a-h	11 a-c	9914.5 b-g	46.5 a-e
14	67.5 c-g	131 L-n	167.5 i-k	25.33 gh	10.5 a-c	6717.5 n-s	39.3 g-L
15	74 a-g	132.5 j-m	168 i-k	33.35 a-h	10 a-c	9298.5 c-j	40.95 c-L
16	68 c-g	134.5 g-j	168 i-k	25.78 gh	9.5 a-c	6819.5 m-s	37.9 i-L
17	81 a-f	133.5 h-k	168.5 h-k	35.69 a-h	10 a-c	9805 b-g	42.2 c-k
18	64 fg	134.5 g-j	175 b-e	48.48 a-h	12.5 a	6213.5 q-s	37.15 kL
19	66 d-g	131 L-n	168 i-k	27.54 d-h	11 a-c	6234.5 q-s	38 h-L
20	71.5 a-g	130 n	170 g-k	31.46 b-h	10 a-c	6954 L-s	46.15 a-f
21	61 g	135 f-i	176 b-e	23.9 h	9.5 a-c	8303 e-q	41.1 c-L
22	81 a-f	137.5 b-d	177.5 a-c	26.17 f-h	10 a-c	8649.5 e-o	44.2 c-i
23	76.5 a-g	138 a-d	179 ab	42.19 a-h	11 a-c	8627.5 e-o	40.15 e-L

24	76.5 a-g	136.5 c-g	176 b-d	28.5 d-h	10.5 a-c	8876 d-m	37.5 j-L
25	71 a-g	134.5 g-j	174.5 c-f	55.9 a-d	12.5 a	10405.5b-d	41.1 c-L
26	73.5 a-g	130.5 mn	167 i-k	27.2 d-h	11 a-c	7812 g-q	45.15 b-g
27	76 a-g	137 b-f	177.5 a-c	61.5 a	12 ab	11235 a-c	52.15 a
28	74.5 a-g	133.5 h-k	176 b-e	52.75 a-g	10 a-c	7115.5 k-s	43.05 c-k
29	76.5 a-g	131.5 k-n	171 f-i	35.68 a-h	11 a-c	9230 c-k	40.55 c-L
30	73.5 a-g	135.5 e-h	176 b-e	46.5 a-h	10.5 a-c	8304.5 e-q	41.8 c-k
31	64 fg	137.5 a-d	178.5 a-c	58.69 a-c	12 ab	5070 s	42.2 c-k
32	61.5 g	137.5 a-d	178 a-c	36.6 a-h	11 a-c	7576 i-q	47 a-c
33	81.5 a-f	138.5 a-c	175 b-e	43.6 a-h	11 a-c	7413 j-r	44.95 c-g
34	76 a-g	135 f-i	176 b-e	54.73 a-f	11.5 ab	7653 h-q	46.85 a-d
35	74.5 a-g	136 d-g	177.5 a-c	35.75 a-h	11 a-c	8981 d-L	45.3 b-g
36	89.5 a	132.6 j-m	167.5 i-k	40.2 a-h	10.5 a-c	9004.5 d-L	39.7 f-L
37	87 ab	132.5 j-m	166.5 jk	40.40 a-h	11 a-c	9193.5 c-k	44.9 c-g
38	64.5 e-g	131 L-n	167.5 i-k	40.75 a-h	8 c	8761 d-n	40.6 c-L
39	71 a-g	131 L-n	168 i-k	30.75 c-h	10 a-c	6786 m-s	45.1 b-g
40	85.5 a-c	133.5 h-k	168.5 h-k	26.68 f-h	10 a-c	11582 ab	46.35 a-e
41	81.5 a-f	133 i-L	168 i-k	39.25 a-h	9.5 a-c	10851.5a-d	44.2 c-i
42	75 a-g	131.5 k-n	166 jk	35.53 a-h	10 a-c	7284 j-r	44.8 c-g
43	64 fg	130.5 mn	170.5 f-i	39 a-h	10.5 a-c	5333 r-s	43.65 c-k
44	72 a-g	132.5 j-m	172.5 e-h	32.88 a-h	10.5 a-c	7125.5 k-s	41.05 c-L
45	82 a-f	135.5 e-h	177 a-d	39.7 a-h	11 a-c	6601 o-s	39.15 g-L
46	75.5 a-g	137 b-f	177.5 a-c	27.13 e-h	11.5 ab	6501.5 p-s	34.7 L
47	78 a-g	135 f-i	175.5 b-e	36.15 a-h	11 a-c	6574 o-s	41.65 c-k
48	80.5 a-g	131 L-n	167 i-k	28.63 d-h	11 a-c	7297.5 j-r	42.3 c-k
49	89.5 a	133 i-L	169 g-k	35.2 a-h	11 a-c	9876 b-g	44.1 c-i
50	72 a-g	140 a	180.5 a	37 a-h	10.5 a-c	7499 j-q	39.15 g-L

*Means followed by different letters differ significantly from each other at 0.05 probability.

Table 7 presents the combined analysis across both Semel and Zenawa locations. The mean square attributed to location or environments demonstrated a significant effect on plant height, days to maturity, leaf area, 1000-grain weight, and total grain yield, excluding spike length. Additionally, genotype exerted a significant effect on all seven traits, while the interaction between genotypes and environment significantly influenced plant height, days to heading, days to maturity, and total grain yield. In contrast, leaf area and spike length exhibited non-significant effects. These findings underscore substantial variations among genotypes when applied in different locations, aligning with previous studies by (6 and 8), which also reported highly significant differences among genotypes for most of the studied traits.

Table 7: Combined analysis for bread wheat genotypes and yield components across both Semel and Zenawa locations.

SOV	df	MS						
		Plant height (cm)	Days to heading (days)	Days to maturity (days)	Leaf area (cm^2)	Spike length (cm)	1000-grain weight (g)	Total grain yield (kg. ha^{-1})
E	1	** 4675.44	** 508.80	** 1884.98	13.77	2.00	** 3501.17	** 540435413.8
rE	2	67.08	1.32	18.77	555.80	0.74	24.04	581240.9
g	49	** 143.61	** 28.12	** 58.84	** 351.52	** 2.69	** 37.16	** 3642920.2
Eg	49	** 62.99	** 1.80	** 4.87	2.360	0.44	** 17.19	** 3217953.3
Error	98	29.62	0.62	2.56	116.12	1.50	6.25	690540.9
Total	199							

** Significance 0.01 probability.

Table 8 presents the mean performance of the genotypes across both Semel and Zenawa locations, revealing substantial diversity in traits. Plant height exhibited a mean of 80.03, ranging from 67.75 to 95.25 cm, with G21 recording the minimum at 67.75 cm and G49 the maximum at 95.25 cm, followed by G45 at 89.75 cm. Days to heading displayed variations, with G9, G20, G26, and G46 exhibiting the earliest values at 128.5 days, 7% earlier over the 138.25 days for the check variety. For days to maturity, G42 and G37 were the earliest at 166 and 166.5 days, respectively, while the check variety exhibited delayed maturity at 180.5 days. Leaf area in cm2 saw G26, G1, and G14 with the highest values at 59.1, 58.8, and 54.6 cm2, respectively, while G2 had the lowest at 24.05 cm2. Notably, increased leaf area correlated positively with 1000-grain weight and total grain yield in these genotypes.

For spike length, G18 recorded the longest at 12.5 cm, followed by G10 and G25 at 12.25 cm, while G38 had the shortest at 9 cm. In terms of 1000-grain weight, G26 had the highest mean value at 43.74g, followed by G2 at 43.2g, with the lowest value at 31.18g. Notably, the mean performance of genotypes exhibited significant variation among the genotypes, indicating diverse sources of variation. Total grain yield across both locations showed G25 with the highest at 8283 kg/ha, followed by G1 at 8211.3 kg. ha^{-1}, while G31 recorded the lowest at 4170.3 kg. ha^{-1}. The Zenawa location outperformed Semel which experiences lower rainfall and temperatures (Table 2). In continuing the evaluation program for the winter season 2023-2024, ten high-yielding genotypes were selected from the two locations for planting in three different locations with varying conditions. These findings align with previous studies by (5, 10 and 16), reinforcing similar observations.

Table 8: Mean performances of the bread wheat genotypes in the two locations.

G	Plant height (cm)			Days to heading (days)		
	L1	L2	Mean	L1	L2	Mean
1	72.5 m-z	83.5 d-r	78 e-m	132.5 L-o	135.5 f-i	134 e-g
2	75 k-y	70.5 q-z	72.75 L-n	133 k-n	132 m-p	132.5 h-k
3	71.50 z	77 i-x	74.25 i-n	128 tu	132.5 L-o	130.25 no
4	81.5 e-t	72.5 m-z	77 e-n	129 st	132.5 L-o	130.75 mn
5	84 d-q	82.5 d-s	83.25 c-j	135 g-j	137.5 b-e	136.25 b
6	93 a-f	75 k-y	84 b-h	132.5 L-o	136.5 d-g	134.5 d-f
7	91 b-h	79.5 f-v	85.25 b-f	132.5 L-o	137 c-f	134.75 c-f
8	84.5 d-p	83 d-s	83.75 b-i	134 i-L	139 ab	136.5 b
9	91.5 a-g	70 r-z	80.75 d-L	127 u	130 q-s	128.5 p
10	83 d-s	79.5 f-v	81.25 d-L	129.5 r-s	132.5 L-o	131 L-n
11	79 g-v	69.5 s-z	74.25 i-n	131.5 n-q	132.5 L-o	132 j-m
12	89 c-j	83.5 d-r	86.25 a-d	133.5 j-m	132.5 L-o	133 g-j
13	76.5 i-x	77 i-x	76.75 e-n	127 u	130.5 p-s	128.75 p
14	86 d-m	67.5 u-z	76.75 e-n	127 u	131 o-r	129 op
15	82.5 d-s	74 L-z	78.25 e-m	129.5 r-s	132.5 L-o	131 L-n
16	82.5 d-s	68 t-z	75.25 g-n	133 k-n	134.5 h-k	133.75 f-h
17	85 d-o	81 e-u	83 c-j	134 i-L	133.5 j-m	133.75 f-h
18	74 L-z	64 x-z	69 mn	131.5 n-q	134.5 h-k	133 g-j
19	85 d-o	66 v-z	75.5 g-n	127 u	131 o-r	129 op
20	77.5 h-x	71.5 o-z	74.5 h-n	127 u	130 q-s	128.5 p
21	74.5 k-z	61 z	67.75 n	132.5 L-o	135 g-j	133.75 f-h
22	86 d-m	81 e-u	83.5 b-j	133 k-n	137.5 b-e	135.25 b-e
23	84.5 d-p	76.5 i-x	80.5 d-L	134 i-L	138 b-d	136 bc
24	89 c-j	76.5 i-x	82.75 c-k	133 k-n	136.5 d-g	134.75 c-f
25	78 g-w	71 p-z	74.5 h-n	131.5 n-q	134.5 h-k	133 g-j
26	91.5 a-g	73.5 L-z	82.5 c-k	127 u	130.5 p-s	128.75 p
27	75.5 j-x	76 i-x	75.5f-n	134 i-L	137 c-f	135.5 b-d
28	89 c-j	74.5 k-z	81.75 c-L	130 q-s	133.5 j-m	131.75 j-m
29	85 d-o	76.5 i-x	80.75 d-L	127 u	131.5 n-q	129.25 op
30	83 d-s	73.5 L-z	78.25 e-m	132 m-p	135.5 f-i	133.75 f-h
31	81 e-u	64 x-z	72.5 L-n	134 i-L	137.5 b-e	135.75 b-d
32	85 d-o	61.5 yz	73.25 j-n	133 k-n	137.5 b-e	135.25 b-e
33	88 c-k	81.5 e-t	84.75 b-g	134 i-L	138.5 a-c	136.25 b
34	88 c-k	76 i-x	82 c-L	132 m-p	135 g-j	133.5 f-i
35	93 a-f	74.5 k-z	83.75 b-i	133 k-n	136 e-h	134.5 d-f
36	95.5 a-d	89.5 c-i	92.5 ab	132 m-p	132.5 L-o	132.25 i-L
37	94.5 a-e	87 d-L	90.75 a-c	129.5 r-t	132.5 L-o	131 L-n
38	83.5 d-r	64.5 w-z	74 j-n	127 u	131 o-r	129 op
39	83 d-s	71 p-z	77 e-n	127 u	131 o-r	129 op
40	86 d-m	85.5 d-n	85.75 b-d	129 st	133.5 j-m	131.25 k-n
41	79 g-v	81.5 e-t	80.25 e-L	129 st	133 k-n	131 L-n
42	83 d-s	75 k-y	79 e-L	127 u	131.5 n-q	129.25 op
43	84 d-q	64 x-z	74 j-n	127 u	130.5 p-s	128.75 p
44	85.5 d-n	72 n-z	78.75 e-L	129 st	132.5 L-o	130.75 mn
45	103 ab	82 d-s	92.5 ab	132 m-p	135.5 f-i	133.75 f-h
46	104 a	75.5 j-x	89.75 a-d	134 i-L	137 c-f	135.5 b-d
47	77 i-x	78 g-w	77.5 e-m	132 m-p	135 g-j	133.5 f-i
48	89 c-j	80.5 fu	84.75 b-g	127 u	131 o-r	129 op
49	101 a-c	89.5 c-i	95.25 a	129.5 r-t	133 kn	131.25 k-n
50	80 f-u	72 n-z	76 f-n	136.5 d-g	140 a	138.25 a

*Means followed by different letters differ significantly from each other at 0.05 probability.

Table 8: Mean performances of the bread wheat genotypes at the two locations (cont'd).

G	Spike length (cm)			Leaf area (cm^2)		
	L1	L2	Mean	L1	L2	Mean
1	11 a-c	12.5 a	11.75 a-c	57.10 a-d	59.5 ab	58.3 ab
2	10.5 a-c	10 a-c	10.25 b-e	24.3 j	23.8 j	24.050 i
3	9.5 a-c	10 a-c	9.75 c-e	41 a-j	41.15 a-j	41.075 a-i
4	10 a-c	9 bc	9.5 de	32.7 b-j	32.8 b-j	32.75 f-i
5	10.5 a-c	10.5 a-c	10.5 a-e	40 a-j	40.83 a-j	40.413 b-i
6	11 a-c	11 a-c	11 a-e	34.25 a-j	35.83 a-j	35.038 e-i
7	10 a-c	10.5 a-c	10.25 b-e	31.55 c-j	33.10 b-j	32.325 f-i
8	9.5 a-c	10 a-c	9.75 c-e	48.25 a-j	50.7 a-j	49.475 a-g
9	11.5 ab	11.5 ab	11.5 a-d	24.35 j	24.83 j	24.588 i
10	12 ab	12.5 a	12.25 ab	38.45 a-j	37.83 a-j	38.138 d-i
11	10 a-c	11 a-c	10.5 a-e	35.35 a-j	36.75 a-j	36.55 d-i
12	9.5 a-c	9.5 a-c	9.5 de	52.3 a-i	55.55 a-f	53.925 a-e
13	10 a-c	11 a-c	10.5 a-e	42.7 a-j	42.63 a-j	42.663 a-i
14	10 a-c	10.5 a-c	10.25 b-e	27.15 h-j	25.33 i-j	26.238 i
15	10.5 a-c	10 a-c	10.25 b-e	33.8 b-j	33.35 b-j	33.575 f-i
16	9.5 a-c	9.5 a-c	9.5 de	27.2 h-j	25.78 h-j	26.488 i
17	9 bc	10 a-c	9.5 de	36.8 a-j	35.69 a-j	36.243 d-i
18	12.5 a	12.5 a	12.5 a	38.1 a-j	38.48 a-j	38.288 d-i
19	10.5 a-c	11 a-c	10.75 a-e	27.95 g-j	27.54 g-j	27.743 hi
20	9.5 a-c	10 a-c	9.75 c-e	30.25 d-j	31.46 c-j	30.855 g-i
21	10 a-c	9.5 a-c	9.75 c-e	25.3 i-j	23.9 j	24.6 i
22	9 bc	10 a-c	9.5 de	26.2 h-j	26.17 h-j	26.1285 i
23	12 ab	11 a-c	11.25 a-d	40.30 a-j	42.19 a-j	41.243 a-i
24	10.5 a-c	10.5 a-c	10.5 a-e	28.75 e-j	28.5 f-j	28.625 hi
25	12 ab	12.5 a	12.25 ab	52.15 a-i	55.9 a-e	54.025 a-d
26	10.5 a-c	11 a-c	10.75 a-e	28.8 e-j	27.2 h-j	28 hi
27	11.5 ab	12 ab	11.75 a-c	56.7 a-d	61.5 a	59.1 a
28	9.5 a-c	10 a-c	9.75 c-e	49.3 a-j	52.75 a-h	51.025 a-f
29	10.5 a-c	11 a-c	10.75 a-e	35.85 a-j	35.68 a-j	35.763 d-i
30	10.5 a-c	10.5 a-c	10.5 a-e	44.8 a-j	46.5 a-j	45.65 a-h
31	11 a-c	12 ab	11.5 a-d	56.85 a-d	58.69 a-c	57.768 a-c
32	12 ab	11 a-c	11.5 a-d	37.55 a-j	36.6 a-j	37.075 d-i
33	10 a-c	11 a-c	10.5 a-e	42.6 a-j	43.6 a-j	43.100 a-i
34	12 ab	11.5 ab	11.75 a-c	54.65 a-g	54.73 a-g	54.688 a-d
35	11.5 ab	11 a-c	11.25 a-d	35.8 a-j	35.75 a-j	35.775 d-i
36	10.5 a-c	10.5 a-c	10.5 a-e	41.6 a-j	40.2 a-j	40.9 a-i
37	11 a-c	11 a-c	11 a-e	38.1 a-j	40.40 a-j	39.25 d-i
38	10 a-c	8 c	9 e	38.85 a-j	40.75 a-j	39.8 c-i
39	9.5 a-c	10 a-c	9.75 c-e	31.3 d-j	30.75 d-j	31.025 g-i
40	10.5 a-c	10 a-c	10.25 b-e	27.75 g-j	26.68 h-j	27.213 hi
41	10.5 a-c	9.5 a-c	10 c-e	38.1 a-j	39.25 a-j	38.675 d-i
42	9.5 a-c	10 a-c	9.75 c-e	34.45 a-j	35.53 a-j	34.988 f-i
43	9.5 a-c	10.5 a-c	10 c-e	38.9 a-j	39 a-j	38.95 d-i
44	10.5 a-c	10.5 a-c	10.5 a-e	31.45 c-j	32.88 a-j	32.163 f-i
45	11 a-c	11 a-c	11 a-e	39.35 a-j	39.7 a-j	39.525 c-i
46	11.5 ab	11.5 ab	11.5 a-d	28.25 g-j	27.13 h-j	27.688 hi
47	10 a-c	11 a-c	10.5 a-e	37.45 a-j	36.15 a-j	36.8 d-i
48	10.5 a-c	11 a-c	10.75 a-e	28.35 f-j	28.63 e-j	28.488 hi
49	10.5 a-c	11 a-c	10.75 a-e	36.6 a-j	35.2 a-j	35.9 d-i
50	9.5 a-c	10.5 a-c	10 c-e	34.85 a-j	37 a-j	35.925 d-i

*Means followed by different letters differ significantly from each other at 0.05 probability.

Table 8: Mean performances of the bread wheat genotypes at the two locations (cont'd).

G	Days to maturity (days)			Total grain yield (kg. ha^{-1})		
	L1	L2	Mean	L1	L2	Mean
1	162 v-w	170 i-o	166 k-m	5623 v-k	10799.5 a-d	8211.3 ab
2	165.5 p-u	167.5 l-r	166.5 j-m	4739 c-m	7912 h-u	6325.5 g-n
3	167 m-r	172.5 e-j	169.75 g-i	5557 w-l	10047 b-g	7802 a-f
4	160.5 w	167.5 l-r	164 m	4765.5 c-m	8976.5 d-m	6871 a-l
5	170.5 i-n	178 a-d	174.25 a-d	4688.5 c-m	9708 b-i	7198.3 a-i
6	167 m-r	177 a-d	172 d-g	4953 a-m	9660 b-j	7306.5 a-h
7	168.5 k-q	177 a-d	172.75 b-f	4093 j-m	12390.5 a	8241.8 ab
8	171 g-l	179 ab	175.25 ab	4760.5 c-m	8074.5 g-t	6417.5 f-n
9	167.5 l-r	169.5 i-p	168.5 h-k	6262.5 s-h	8360.5 f-r	7311.5 a-h
10	167.5 l-r	173 e-i	170.25 f-i	6290.5 s-h	6507 r-g	6398.8 f-n
11	164.5 q-v	168 k-r	166.25 j-m	4352 h-m	9064 d-l	6708 c-n
12	168 k-r	167.5 l-r	167.75 i-l	6147 t-j	10216.5 b-f	8181.8 ab
13	162.5 t-w	168 k-r	165.25 lm	5900.5 u-j	9914.5 b-h	7907.5 a-e
14	162 v-w	167.5 l-r	164.75 m	5178 z-m	6717.5 o-e	5947.8 h-n
15	162.5 t-w	168 k-r	165.25 lm	5173 z-m	9298.5 c-k	7235.8 a-h
16	162.5 t-w	168 k-r	165.25 lm	5184 z-m	6819.5 o-c	6001.8 h-n
17	164.5 q-v	168.5 k-q	166.5 j-m	4268.5 h-m	9805 b-i	7036.8 a-k
18	168.5 k-q	175 c-g	171.75 d-g	4351 h-m	6213.5 t-i	5282.3 no
19	162.5 t-w	168 k-r	165.25 lm	4508 f-m	6234.5 t-h	5371.3 m-o
20	167 m-r	170 i-o	168.5 h-k	5124.5 z-m	6954 m-z	6039.3 h-n
21	169.5 i-p	176 b-e	172.75 b-f	3237 m	8303 f-s	5770 i-n
22	169.5 i-p	177.5 a-d	173.5 a-e	3689.5 k-m	8649.5 e-p	6169.5 h-n
23	168 k-r	179 ab	173.5 a-e	4379.5 h-m	8627.5 e-q	6503.5 e-n
24	170.5 i-n	175 b-e	173.5 a-e	4772 b-m	8876 d-n	6824 b-m
25	167 m-r	174.5 d-h	170.75 e-h	6160.5 t-j	10405.5 b-e	8283 a
26	161 vw	167 m-r	164 m	5841 u-j	7812 i-u	6826.5 b-m
27	172 f-k	177.5 a-d	174.75 a-c	4833 bm	11235 a-c	8034 a-d
28	167.5 l-r	176 b-e	171.75 d-g	4227.5 c-m	7115.5 l-z	5921.5 h-n
29	166.5 n-s	171 h-m	168.75 h-j	4508 f-m	9230 d-k	6869 a-l
30	169.5 i-p	176 b-e	172.75 b-f	4884 a-m	8304.5 f-s	6594.3 d-n
31	170.5 i-n	178.5 a-c	174.5 a-d	3470.5 k-m	5070 z-m	4270.3 o
32	169 j-p	178 a-d	173.5 a-e	5083.5 z-m	7576 k-w	6329.8 g-n
33	168.5 k-q	175 c-g	171.75 d-g	4134 i-m	7413 k-w	5773.5 i-n
34	168.5 k-q	176 b-e	172.25 c-f	4552.5 f-m	7653 i-v	6102.8 h-n
35	169 j-p	177.5 a-d	173.25 a-e	6594.5 q-g	8981 d-m	7787.8 a-f
36	161.5 vw	167.5 l-r	164.5 m	6316.5 r-h	9004.5 d-m	7660.5 a-g
37	161 vw	166.5 n-s	163.75	6859.5 n-z	9193.5 d-k	8026.5 a-d
38	162 vw	167.5 l-r	164.75m	7389.5 k-x	8761 e-o	8075.3 a-c
39	162.5 t-w	168 k-r	165.25 lm	5569.5 w-k	6786 o-d	6177.8 h-n
40	162 v-w	168.5 k-q	165.25 lm	4995.5 a-m	11582 ab	8288.8 a
41	164 r-w	168 k-r	166 k-m	4585.5 f-m	10851.5 a-d	7718.5 a-g
42	163 s-w	166 o-t	164.5 m	5080 z-m	7284 k-y	6182 h-n
43	167 m-r	170.5 i-n	168.75 h-j	5672 v-k	5333 x-l	5502.5 l-o
44	168 k-r	172.5 e-j	170.25 f-i	5247 y-m	7125.5 l-z	6186.3 h-n
45	168.5 k-q	177 a-d	172.75 b-f	4720 d-m	6601 p-f	5660.5 k-n
46	169.5 i-p	177.5 a-d	173.5 a-e	4952.5 a-m	6501.5 r-g	5727 j-n
47	168.5 k-q	175.5 b-f	172 d-g	5266 y-m	6574 q-g	5920 h-n
48	161.5 vw	167 m-r	164.25 m	4926.5 a-m	7297.5 k-y	6112 h-n
49	161 vw	169 j-p	165 m	4500.5 g-m	9876 b-h	7188.3 a-j
50	171 h-m	180.5 a	175.75 a	5945 u-j	7499 k-w	6722 c-n

*****Means followed by different letters differ significantly from each other at 0.05 probability.

Table 8: Mean performances of the bread wheat genotypes at the two locations (cont'd).

G	1000-grain weight (g)		
	L1	L2	Mean
1	35.1 r-f	43.850 c-l	39.475 a-i
2	40.7 d-t	45.7 b-g	43.2 ab
3	30.65 c-i	38 j-z	34.325 l-p
4	33.6 w-h	45.65 b-g	39.625 a-i
5	32.55 y-h	43.70 c-m	38.125 e-n
6	34.95 r-f	46.1 b-f	40.525 a-g
7	34.6 t-f	51.350 ab	42.975 a-c
8	36.2 p-d	40.35 e-u	38.275 d-m
9	33.4 x-h	41.4 c-q	37.4 e-o
10	38.8 i-y	47.05 a-c	42.925 a-c
11	25.350 i	42.55 c-o	33.95 m-p
12	41.05 c-r	44.5 c-i	42.775 a-c
13	34.3 u-g	46.5 b-e	40.400 a-h
14	37.5 m-b	39.3 h-x	38.400 d-l
15	33.9 v-h	40.95 c-s	37.425 e-o
16	32.8 y-h	37.9 k-a	35.350 i-p
17	31.35 b-h	42.2 c-p	36.775 g-o
18	29.7 c-i	37.15 n-b	33.425 op
19	35.75 q-e	38 j-z	36.875 g-o
20	35.75 q-e	46.15 b-f	40.95 a-f
21	28.15 g-i	41.1 c-r	34.625 k-p
22	35.75 q-e	44.2 c-j	39.975 a-h
23	32.7 y-h	40.15 f-v	36.425 g-o
24	30.3 d-i	37.5 m-b	33.900 n-p
25	37.5 m-b	41.1 c-r	39.30 b-j
26	42.35 c-p	45.15 c-h	43.75 a
27	33.45 w-h	52.150 a	42.8 a-c
28	36.75 o-c	43.05 c-n	39.9 a-h
29	31.65 a-h	40.55 e-u	36.100 h-o
30	34.3 u-g	41.0 c-q	38.05 e-n
31	27.75 hi	42.2 c-p	34.975 j-p
32	35.1 r-f	47 a-c	41.05 a-f
33	28.1 hi	44.95 c-i	36.525 g-o
34	35.75 q-e	46.850 a-d	41.30 a-e
35	34.7 s-f	45.3 c-h	40 a-h
36	32.55 y-h	39.7 g-w	36.125 h-o
37	40.15 f-v	44.9 c-i	42.525 a-d
38	33.15 x-h	40.6 d-t	36.875 g-o
39	40.85 c-t	45.1 c-h	42.975 a-c
40	39.3 h-x	46.35 b-f	42.825 a-c
41	35.8 q-e	44.2 c-j	40 a-h
42	41.75 c-q	44.8 c-i	43.275 ab
43	33.2 x-h	43.65 c-m	38.425 d-l
44	29.75 e-i	41.05 c-r	35.40 i-p
45	37.75 l-a	39.15 h-x	38.45 d-l
46	29.05 f-i	34.7 s-f	31.185 p
47	35.85 q-e	41.65 c-q	38.750 c-k
48	37.35 n-b	42.3 c-p	39.825 a-h
49	32.2 z-h	44.1 c-k	38.150 e-n
50	33.4 x-h	39.15 h-x	36.275 g-o

*Means followed by different letters differ significantly from each other at 0.05 probability.

Conclusions

Significant differences were seen among the 50 wheat genotypes in most agronomic traits under rain-fed conditions, with the Zenawa location outperforming Semel. Ten high-yielding and well-adapted genotypes (G1, G6, G7, G12, G13, G25, G27, G37, G38, and G40) were identified and recommended for further multi-location testing. These results support the continued evaluation and selection of improved genotypes to enhance wheat production in the diverse environments of the Iraqi Kurdistan Region.

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