السلوك الوراثي والاستجابة للانتخاب لبعض التراكيب الوراثية من القمح الطري تحت ظروف البيئات الجافة وشبه الجافة

Genetic Behavior and Selection Response of Some Bread Wheat (*Triticum aestivum* L.) Genotypes under Arid and Semiarid Environments

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الملخص

يتمثل الهدف الرئيس لبرامج تربية محصول القمح الطري المنفذة بأكساد في اختيار الطرز الوراثية الواعدة من القمح الطري ذات القدرة الإنتاجية المرتفعة في البيئات الجافة وشبه الجافة. أجريت الدراسة بهدف تقييم عدد من الصفات الحقلية ودراسة التنوع الوراثي وتحليل المكونات الأساسية لـعدد 168 طرازا وراثيًا من القمح الطري تم اختيارها من الجيل الخامس F_5. تم تقييم الطرز الوراثية اعتمادا على تسع صفات مختلفة، موعد طرد 50% من السنابل (يوم)، موعد النضج (يوم)، ارتفاع النبات (سم.)، عدد السنابل/نبات، عدد السنيبلات/السنبلة، عدد الحبوب/السنبلة، وزن 1000 حبة (غ.) ، محصول الحبوب/نبات (غ.) ومحصول القش/النبات (غ.). وتم زراعتها ضمن تصميم القطاعات العشوائية الكاملة بثلاثة مكررات تحت الظروف البعلية (المطرية) في محطتي بحوث إزرع وكفردان للتجارب الزراعية التابعتين للمركز العربي - أكساد في محافظتى درعا ، سوريا و البقاع ، لبنان ، لموسمين زراعيين على التوالى (17/2016 و 18/2017). يمكن تلخيص أهم النتائج التي تم الحصول عليها على النحو التالي:

- أشار تحليل التباين إلى تجانس الفروقات المعنوية بين السنوات لمعظم الصفات المدروسة. بينما أظهرت الطرز الوراثية تباين عالى ($P\leq 0.01$) بالنسبة الى جميع الصفات المدروسة في كلا الموسمين والتحليل التجميعي مما يشير إلى وجود مقدار كبير من التباين بين الطرز الوراثية لكل صفة.
- بالنسبة لصفتى موعد طرد 50% من السنابل وموعد النضج، أشارت النتائج الى تميز السلالة رقم 14 تحت ظروف منطقة إزرع و ثلاث سلالات رقم 52 و 90 و 128 تحت ظروف منطقة كفردان في صفتى التبكير بالطرد والنضج خلال موسمى الزراعة. بينما، تفوقت أربع سلالات رقم 33 و 71 و 109 و 147 في محصول الحبوب /نبات حيث سجلت أعلى متوسط عبر المواسم وضمن كلا

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الموقعين حيث تراوحت القيم بين 27.14 جم للسلالة 147 تحت ظروف منطقة إزرع و 29.40 جم للسلالة 33 تحت ظروف منطقة كفردان. بينما، أظهرت نتائج معامل الارتباط وجود علاقة ارتباط موجب وعالى المعنوية بين محصول الحبوب/نبات وصفات عدد السنابل/نبات (0.894** و0.901**)، عدد السنيبلات/ السنبلة (0.723** و 0.744**)، عدد الحبوب/بالسنبلة (0.696** و0.744**) و 1000 حبة (0.681** و0.556**) عبر المواسم و تحت ظروف كلا الموقعين على الترتيب.

- أظهر التحليل المبدئى للمكونِات الأساسية (PCA) وجود تباين عالى بين الطرز الوراثية وتقسيمها إلى مجموعتين اعتمادا على الصفات المدروسة، حيث فسر المكونان الأساسيان الأول والثاني نسبة 84.74 % و84.59% من التباين الكلي بالمنطقتين على الترتيب، وتضمن المكون الأول معظم تفسيرات التباين بين الطرز الوراثية (58.70% و 60.98% تحت ظروف منطقتى إزرع وكفردان، على التوالي). والمكون الثاني أعطى تفسيرا لمكونات التباين بنسبة 25.04% و23.61% تحت ظروف منطقتى ازرع و كفران على التوالى.
- أوضح التحليل العنقودي لإنقسام الطرز الـ 168 المدروسة، إلى أربعة عناقيد رئيسية، وقسمت إلى 15 و10 تحت عنقود لكل من منطقتى إزرع وكفردان على التوالي. كانت المجموعة الأولى (I) والثانية (II) هي الأكبر وتحتوي على 24 و20 طرزا وراثيًا (شكلت نسبة 14.28٪ و 11.90٪ من إجمالي الطرز المدروسة، على الترتيب) تحت ظروف منطقة إزرع، وكذلك اشتملت المجموعات الأولى (I) والثانية (II) والثالثة (III) والرابعة (IV) على أكبر عدد من الطرز الوراثية 19 و 22 و 33 و 25 تركيبًا وراثيا (شكلت النسب 11.31 و 13.09 و 19.64٪ و 14.88٪ من مجموع الطرز الوراثية على الترتيب) تحت ظروف منطقة كفردان.
- تشير هذه النتائج إلى أن الطرز الوراثية عالية الغلة رقم 33 و 71 و 109 و 147 لديها قدرة أكبر على التكيف مع الاجهادات البيئية تحت ظروف الزراعة البعلية في كلا الموقعين ويمكن استخدامها في برامج التربية لتطوير طرز وراثية عالية الغلة أو توزيعها على المزارعين المستهدفين في البيئات الجافة وشبه الجافة.

الكلمات المفتاحية: القمح الطري، الظروف المطرية، الارتباط المظهري، تحليل المكونات الأساسية، التحليل العنقودي.

Abstract

Selection for newly promising bread wheat genotypes with high yield potential under arid and semi-arid conditions is the main objective of wheat breeding programs in ACSAD. The present study was carried out to evaluate agronomic traits, genetic diversity and principle component analysis of 168 bread wheat genotypes selected in F_5 generation. The genotypes were evaluated for nine different yield contributing characters viz., days to heading, maturity date, plant height, number of spikes/plant, number of spikelets/spike, number of grains/spike, 1000-kernel weight, grain yield/plant and straw yield/plant and were grown in randomized complete block design with three replications under rainfed conditions at Izraa and kafrdan Agricultural Experiment Stations of ACSAD at Daraa governorate, Syria and Bekaa governorate, Lebanon, respectively for two growing seasons (2016/17 and 2017/18). The most important results obtained can be summarized as follows:

- The combined analysis of variance indicated the homogeneous of significant differences between years for most studied traits. The genotypes exhibited highly significant ($P\leq 0.01$) for all traits studied in both and across seasons indicating considerable amount of variation among genotypes for each trait.
- For days to heading (50%) and maturity dates the line 14 under Izraa as well as the three lines Line 52, Line 90 and Line 128 under kafrdan were the earliest across seasons. While, for grain yield/plant the four new bred lines; 33, 71, 109 and 147 recorded the highest mean across seasons and under both sites which had values ranged from 27.14g for line 147 under Izraa and 29.40 g for line 33 under Kafrdan conditions. Meanwhile, grain yield was positively correlated with each of no. of spikes/plant (0894** and 0.901**), no. of sikelets/spike (0.723** and 0.744**), no. of grains/spike

0.696** and 0.744**) and 1000-kernel (0.681** and 0.556**) across seasons under the two sites, respectively.

- Principle component analysis (PCA) showed existence of a high level of variability among the genotypes and allowed the division of the collection of genotypes into two groups (component 1 and 2) which gave an explanation of 84.74% and 84.59% of the total variance in the two sites. The first component of PCA could justify most of the variance among genotypes (58.70% and 60.98% under Izraa and kafrdan conditions, respectively). While, the second component could justify more than 25.04% and 23.61% under Izraa and kafrdan, respectively.
- Cluster analysis of euclidean distances, classified the 168 genotypes into four main clusters divided into 15 and 10 intra cluster under Izraa and Kafrdan, respectively. The first (I) and second (II) clusters was the largest and contained 24 and 20 genotypes (14.28% and 11.90% of total genotypes, respectively) under Izraa as well as the first (I), second (II), third (III) and fourth (IV) clusters recorded the highest number of sets; 19, 22, 33 and 25 genotypes (11.31, 13.09, 19.64 % and 14.88% of total genotypes, respectively) under Kafrdan.
- These results indicate that the high yielding genotypes 33, 71, 109 and 147 have more adaptability for under rainfed conditions in both sites and could be used in breeding programs to develop high yielding genotypes or distributed to the targeted farmers under arid and semi-arid environments.

Key words: Bread wheat, Rained conditions, Phenotypic correlation, Principle Component Analysis, Cluster analysis.

Introduction

Bread Wheat (*Triticum aestivum* L. emend, Fiori & Paol.) is one of the most important cereal crops of the world and occupying more than 90% of cultivated area followed by durum wheat (*Triticum durum var, turgidum* L.) (9- 10%); both in terms of area (223.5 million hectare) and production (765.41 million tons) during 2019/2020 (FAO, 2020), which provides 20 percent of the calories and protein for the world’s population food (Braun *et al*., 2010 and Moosavi *et al*., 2017). Wheat cultivation area reached 8.4 million hectare produced 2.6 million tons in the Arab world is concentrated at the level of the Arab world in the countries of Morocco, Algeria, Egypt, Syria and Iraq which ranks first in terms of cultivated area and production (AOAD, 2018),

Wheat crop plays a key role in the national economy of developing countries according to the persistent increasing of the world population (Ataei *et al*. 2017). Most of wheat cultivated areas are located in arid and semi-arid regions where abiotic stresses, especially drought stress, are a major constraint for crop production (Özturk *et al.,* 2014 and Tahmasebi *et al*. 2014). Wheat breeding programs were aimed to developing new tolerant genotypes generally for abiotic stresses and maintaining their production capacity under drought-prone areas which could contribute in the achievement of food security for the foreseeable future.

Genetic diversity (D^2 statistic) which developed by Mahalanobis (1936) and selection procedures provides a measure of the magnitude of divergence between biological populations and the relative contribution of each component character to the total divergence which considered to be essential for breeding crops under targeted environments, which considered to be more reliable in the selection of potential parents for hybridization program (Maurya and Singh, 1977, Falconer and Mackay, 1996 and Fouad, 2020).

Estimation of genetic diversity based on genetic distance (Euclidean distance) is useful for wheat breeding as one of tools for parental selection to enhance the new genetic recombination and maximize the transgressive segregation for increase yield Khodadadi *et al*. (2011) and Poudel *et al*. (2017). Principal component analysis (PCA) identifies plant traits which characterize the distinctness among selected genotypes and classification the population into groups of distinct orders based on similarities in one or more characters, and thus guide in the choice of parents for hybridization (Beheshtizadeh *et al*. 2013). Several genetic diversity studies used Euclidean distance based on qualitative and quantitative traits as well as WARD method in order to select genetically distant superior genotypes for hybridization, which bearing the desired traits from different clusters could be exploited in breeding wheat programs and improving grain yield under targeted environments (Rani *et al.* 2018, Kandel *et al.* 2018, Santosh *et al*. 2019 and Motlatsi and Mothibeli 2020)

The present investigation objective is evaluating the magnitude of genetic diversity of 168 bread wheat genotypes by using cluster analysis and principal component analysis, for its utilization which could be parents in further wheat breeding programs under rainfed conditions in the two sites Izraa, Syria and Kafrdan, Lebanon.

Materials and Methods

Field experiments were conducted under rainfed conditions at two regions; Izraa Agricultural Research Station of ACSAD, Daraa governorate, Syria (32.8449° N, 36.2251° E) semi-dry and kafrdan Agricultural Research Station of ACSAD, Bekaa governorate, Lebanon (34.017° N, 36.050° E) sub-humid regions during the two consecutive growing seasons (2016/17 and 2017/18) to evaluate the response of 168 selected genotypes in F_5 and their 21 parents of bread wheat; names, sources and pedigree/or selection history of tested genotypes are presented in Table (1). Sowing dates were Nov. 10 and 15 in the 1st and 2nd season, respectively. Meteorological data presented in Table (2) show that the mean of temperature, and amount of rainfall every month in each season in both locations.

The experimental design was a randomized complete block with three replications. The plot area was of 3.0 x 3.5 m. grains were sown in rows, 30 cm apart. All the recommended cultural practices were precisely applied. The investigated recorded traits were recorded for each plot: days to heading (50%) (days), maturity date (days), plant height (cm.), number of spikes/plant, number of spikelets/spike, number of grains/spike, 1000-kernel weight (g.), grain yield/plant (g.) and straw yield/plant (g.) were recorded. Data were subjected to the combined analysis of variance after seasonal homogeneity F test for each environment, as outlined by Steel and Torrie (1984). All statistical analyses were performed using the program Genes, version 2018.25 (Cruz, 2013). Phenotypic correlation coefficients were also calculated for different pairs of traits according to Snedecor and Cochran (1989). Principal component analysis (PCA) with eigenvalues due to the variances of the coordinates on each principal component axis greater than one was performed using (SPSS v. 16 2010) software. Hierarchical cluster analysis (CA) was carried out on means across blocks and years using Ward’s minimum variance method as a clustering algorithm (Williams, 1976) and squared Euclidian distance as a measure of dissimilarity (Ward, 1963).

Table 1. Name, cross/pedigree and origin of the parental genotypes.

Genotypes	Cross/Pedigree	Origin
Line-1	IRQIPAW35 S5B-9B-98/ABUZIG-4	ICARDA*
Line-2	ATTILA-3//NESMA*2/261-9/3/JOHAR-10	ICARDA
Line-3	PAURAQUE	ICARDA
Line-4	TRCH//PRINIA/PASTOR	ICARDA
Line-5	QUAIU	ICARDA
Line-6	CHEN/AEGILOPS SQUARROSA (TAUS)//BCN/3/BAV92/..	CIMMYT**
Line-7	TEPOCA+LR34/ATTILA/TILHI/3/ATTILA*2/PBW65	CIMMYT
Line-8	PFAU/WEAVER//SKUZ/BAV92/3/PBW343*2/KUKUNA	CIMMYT
Line-9	ATTILA/3*BCN//BAV92/3/TILHI/5/BAV92/3/PRL/…	CIMMYT
Line-10	C80.1/3*BATAVIA//2*WBLL1/5/REH/HARE//2*BCN/…	CIMMYT
Line-11	FRET2*2/4/SNI/TRAP#1/3/KAUZ*2/TRAP//KAUZ*2/…	CIMMYT
Line-12	WBLL1*2/VIVITSI/4/D67.2/266.270//AE.SQUARROSA(320)/3/…	CIMMYT
Line-13	ACSAD 1196	ACSAD***
Line-14	ACSAD 1236	ACSAD
Line-15	ACSAD 1238	ACSAD
Line-16	ACSAD 1240	CIMMYT
Line-17	PRL/2*PASTOR*2//FH6-1-7	CIMMYT
Line-18	ONIX/ROLF07	CIMMYT
Line-19	GK ARON/AG SECO 7846//2180/4/2*MILAN/KAUZ//PRINIA/3/…	CIMMYT
Line-20	YUNMAI48//2*WBLL1*2/KURUKU	CIMMYT
Line-21	ROLF07/SRTU//TACUPETO F2001/BRAMBLING	CIMMYT

* ICARDA ; International Center of Agricultural Research in the Dry Areas.

**CIMMYT; Centro International de Mejoramiento de Maize Y Trigo (Mexico) = International maize and wheat improvement center.

***ACSAD ;The Arab Center for the Studies of Arid Zones and Dry Lands.

Table 2. Monthly average weather data at the two sites Izraa and kafrdan during two growing seasons 2016/17 and 2017/18.

Site	Month	Season (2016-2017)			Season (2017-2018)		
		T.† (C°)		Amount Rainfall (mm)	T.† (C°)		Amount Rainfall (mm)
		Max.	Min.		Max.	Min.	
Izraa	**November**	21.42	11.34	2.08	23.80	12.60	2.31
	December	15.40	8.87	6.30	17.11	9.86	7.00
	January	11.14	6.08	34.68	13.10	7.15	40.80
	February	13.15	4.59	35.70	15.47	5.40	42.00
	March	19.30	5.87	2.55	22.70	6.90	3.00
	April	22.07	8.93	12.75	25.96	10.50	15.00
	May	25.95	11.86	64.35	28.83	13.18	71.50
	June	32.51	15.61	0.00	36.12	17.34	0.00
Mean		20.60	9.33	Tot. =163.45	22.89	10.37	Tot. =181.60
Kafrdan	**November**	27.85	13.61	6.24	30.94	15.12	6.93
	December	18.90	10.06	17.85	22.24	11.832	21
	January	14.48	7.29	104.04	17.03	8.58	122.4
	February	17.09	5.51	107.10	20.11	6.48	126
	March	25.08	7.04	7.65	29.51	8.28	9
	April	30.38	11.34	40.50	33.75	12.6	45
	May	33.73	14.23	130.50	37.48	15.816	145
	June	42.26	18.73	0.00	46.96	20.808	0
Mean		**26.78**	**11.20**	**Tot. =427.80**	**29.75**	**12.44**	**Tot. = 475.33**

†T. = Temperature

Results and Discussion

Analysis of variance:

The test of homogeneity of error variance made using error mean squares of the two seasons revealed that error mean squares are homogeneous for all the studied traits. Mean squares of analysis of variance for each season in 2016/17 and 2017/18 and their combined analysis across seasons for the investigated traits of bread wheat genotypes are given in table (3). Mean squares of the main source of variation, i.e. seasons (S.) and genotypes (G.) were found highly significant (P≤0.5 or 0.01) for all traits studied in both sites and across seasons, suggesting that all traits were markedly affected by drought stress under arid and semi-arid regions in both sites, respectively. Results showed that the presence of wide range of differences between genotypes concerning the most investigated traits. However, the variance due to interaction between genotypes and seasons (G×S) was also highly significant for the investigated traits in combined analysis, except for days to heading 50% under Izraa and Kafrdan conditions. Similar results were in agreement with obtained by Birhanu *et al.* (2017), Getachew *et al.* (2017), Kandel *et al.* (2018), Al-Otayk (2019), Devesh *et al.* (2019) and Fouad (2020).

Table 3. Mean squares of bread wheat genotypes (G) for different studied traits in 2016/17 and 2017/18 seasons (S) and combined analysis under rainfed conditions in the two sites.

Sites	**Season**	**First season**		**Second season**		**Combined**				
	Mean Square	**G.**	**Error**	**G.**	**Error**	**S.**	**Rep. (R)/S.**	**G.**	**G.×S.**	**Error**
Izraa	**d.f.**	**167**	**334**	**167**	**334**	**1**	**2**	**167**	**167**	**334**
	Days to heading (50%) (days)	**255.84****	**9.05**	**241.00****	**8.51**	**225.71**	**138.60**	**496.73****	**20.11**	**348.42**
	Maturity date (days)	**432.36****	**15.30**	**407.29****	**14.39**	**325.73****	**341.21**	**739.46****	**500.19****	**419.83**
	Plant height (cm.)	**198.71****	**1.48**	**173.52****	**1.75**	**850.25****	**42.18**	**365.39****	**306.84****	**186.12**
	No. of spikes/plant	**1.33****	**0.01**	**2.45****	**0.01**	**1036.70****	**0.49**	**103.08****	**100.70****	**1.89**
	No. of spikelets/spike	**32.77****	**0.10**	**34.51****	**0.08**	**10209.37****	**5.65**	**559.94****	**507.33****	**33.64**
	No. of grains/spike	**663.58****	**2.01**	**698.93****	**1.71**	**10212.47***	**114.51**	**1213.88****	**848.63****	**681.26**
	1000-kernel weight (g.)	**93.49****	**0.38**	**65.48****	**0.36**	**1108.22****	**27.68**	**151.78****	**107.20****	**79.49**
	Grain yield/plant (g.)	**44.05****	**0.13**	**24.20****	**0.10**	**1208.73****	**6.71**	**262.81****	**105.45****	**34.13**
	Straw yield/plant (g.)	**462.97****	**6.72**	**266.52****	**8.27**	**919.14****	**235.01**	**678.41****	**451.09****	**364.75**
Kardan	**Days to heading (50%) (days)**	**341.04****	**8.21**	**362.11****	**8.74**	**316.89**	**397.67**	**702.99****	**0.16**	**351.57**
	Maturity date (days)	**458.66****	**14.31**	**611.97****	**14.78**	**663.67****	**23.02**	**1047.61****	**682.46****	**535.31**
	Plant height (cm.)	**189.37****	**1.75**	**255.00****	**1.44**	**238.58****	**143.12**	**430.49****	**313.88****	**222.18**
	No. of spikes/plant	**2.43****	**0.01**	**1.51****	**0.02**	**1500.45****	**0.50**	**503.23****	**500.71****	**1.97**
	No. of spikelets/spike	**34.68****	**0.08**	**34.60****	**0.09**	**7139.46****	**5.67**	**561.76****	**507.51****	**34.63**
	No. of grains/spike	**702.25****	**1.69**	**700.65****	**1.92**	**6145.70***	**114.55**	**2250.63****	**1152.27****	**701.45**
	1000-kernel weight (g.)	**67.40****	**0.37**	**104.56****	**0.38**	**221.33****	**28.47**	**263.07****	**108.89****	**85.98**
	Grain yield/plant (g.)	**24.35****	**0.10**	**45.10****	**0.12**	**359.79****	**6.80**	**173.91****	**95.54****	**34.72**
	Straw yield/plant (g.)	**268.04****	**8.10**	**470.42****	**6.37**	**645.88****	**94.93**	**686.74****	**651.72****	**369.23**

*, ** denote significance at 0.05 and 0.01 probability levels, respectively.

Performance of bread wheat genotypes:

The highest mean performance values for different selected 25 from 168 lines of bread wheat for all traits under the two sites Izraa and kafrdan conditions for combined data across seasons are presented in the two Tables 4 and 5. For days to heading (50%) and maturity date the line 14 (107.25 days) under Izraa as well as the three lines Line 52 (105.36days), Line 90 (107.06days) and Line 128 (102.20days) under kafrdan were the earliest respectively across seasons. While, the two lines; Line 61 (97.16 cm.) and Line 99 (97.57 cm.) under Izraa and the two lines; Line 23 (102.02 cm.) and Line 35 (106.45 cm.) under kafrdan were the tallest genotypes recorded the highest values for plant height. On the other hand, the Line 14 (76.79 cm.) under Izraa and the two lines; Line 52 (76.58cm.) and Line 128 (74.28cm.) under kafrdan were the shortest genotype (Tables 4 and 5).

Based on average of two seasons (Tables 4 and 5) no. of spikes /plant, no. of spikelets/spike, no. of grains/spike and 1000 kernel weight ranged from (5.50 for Line 14 to 6.91 for Line 76), (16.24 for Line 76 to 24.99 for Line 109), (73.09 for Line 76 to 112.45 for Line 109), (38.57 g. for Line 14 to 58.10 g. for Line 76) under Izraa conditions and (5.32 for Line 128 to 7.22for Line 35), (15.51 for Line 29 to 26.11for Line 33), (84.81for Line 30 to 117.49 for Line 33), (37.35g. for Line 128 to 60.85g. for Line 35) under Kafrdan respectively, reflecting high variance of these traits under the two sites.

For grain yield/plant the four new bred lines; 33, 71, 109 and 147 recorded the highest mean across seasons and under both sites which had values ranged from 27.14g for line 147 under Izraa and 29.40 g for line 33 under Kafrdan conditions. On the other hand, two lines ; 69 and 136 recorded the lowest means in combined under both sites. Whereas, the three lines; 33, 71 and 109 recorded the highest values in combined across seasons for straw yield/plant. Although the variation of means for most genotypes is attributed mainly to distribution of the amount of rainfall within months and development stages across the growing seasons and under both sites. From previous data, we observed that there is a kind of stability from year to year in grain yield and its components for some of bread wheat genotypes as the low yielding genotypes, Line 69 and Line 136 and high or relatively high yielding genotypes the four Lines; 33, 71, 109 and 147. The present investigation is in conformity with early findings in bread wheat by Getachew *et al*. (2017), Poudel *et al*. (2017), Rani *et al.* (2018), Wani *et al.* (2018), Santosh *et al.* (2019), and Fouad (2020).

Table 4. Mean performance of the highest 25 from 168 bread wheat genotypes for combined data across seasons under rainfed at Izraa conditions.

Genotypes	Days to heading (50%)	Maturity date (days)	Plant height (cm.)	No. of spikes/ plant	No. of spikelets/ spike	No. of grains/ spike	1000-kernel weight (g.)	Grain yield/ plant (g.)	Straw yield/ plant (g.)
Line 14	107.25	139.43	76.79	5.50	20.74	93.31	38.57	23.32	78.05
Line 22	126.67	164.67	89.88	6.10	20.69	93.08	46.56	24.32	65.65
Line 31	128.26	166.73	81.70	6.25	20.60	92.72	41.36	23.86	70.77
Line 32	116.38	151.29	85.68	6.41	23.23	104.53	45.05	23.05	62.23
Line 33	125.48	163.13	89.84	6.43	24.26	109.17	45.12	27.28	91.32
Line 52	115.45	150.08	82.65	5.92	22.32	100.44	41.51	25.10	84.02
Line 60	129.92	168.90	92.19	6.26	21.22	95.47	47.76	24.94	67.34
Line 61	122.61	159.40	97.16	6.13	22.45	101.04	48.40	25.33	75.78
Line 69	131.54	171.01	83.80	6.41	21.16	95.10	42.42	22.47	72.58
Line 70	119.36	155.17	87.88	6.57	23.82	107.21	46.20	23.64	63.82
Line 71	128.70	167.31	92.15	6.60	24.85	111.97	46.28	27.98	93.67
Line 72	123.02	159.92	82.67	6.62	23.27	104.71	46.17	23.26	73.29
Line 76	127.81	166.15	89.33	6.91	16.24	73.09	58.10	23.32	67.20
Line 90	110.47	143.61	79.09	5.66	21.36	96.11	39.72	24.02	80.40
Line 98	130.47	169.61	92.58	6.29	21.31	95.88	47.96	25.05	67.62
Line 99	123.13	160.07	97.57	6.16	22.55	101.47	48.60	23.43	76.10
Line 107	132.10	171.73	84.15	6.43	21.22	95.50	42.60	24.58	72.89
Line 108	119.87	155.83	88.25	6.60	23.93	107.67	46.40	23.74	64.09
Line 109	129.25	168.02	92.54	6.62	24.99	112.45	46.48	28.10	94.06
Line 110	123.54	160.60	83.02	6.65	23.37	105.16	46.37	25.36	73.60
Line 128	111.98	145.58	80.18	5.74	21.65	97.43	40.27	24.35	81.50
Line 136	126.02	163.83	89.42	6.07	20.58	92.61	46.32	22.19	65.32
Line 145	127.60	165.88	81.28	6.21	20.50	92.24	41.15	23.74	70.41
Line 147	124.84	162.29	89.38	6.40	24.14	108.62	44.89	27.14	90.86
Line 166	117.20	152.36	83.91	6.01	22.66	101.96	42.14	25.48	85.29
Mean	123.16	160.10	86.92	6.28	22.12	99.56	45.06	24.60	75.51
Over all mean	114.42	148.74	83.05	5.54	17.53	78.90	43.92	19.60	58.96
L.S.D.0.05									
G	3.37	2.38	4.77	1.42	1.37	2.01	4.55	3.32	6.43
S	0.63	0.47	0.90	0.68	0.53	0.96	22.19	16.08	31.38
S× G	23.56	14.18	33.32	60.47	30.28	90.15	0.39	0.28	0.55

Table 5. Mean performance of the highest 25 from 168 bread wheat genotypes for combined data across seasons under rainfed at kafrdan conditions.

Genotypes	Days to heading (50%)	Maturity date (days)	Plant height (cm.)	No. of spikes/ plant	No. of spikelets/ spike	No. of grains/ spike	1000- kernel weight (g.)	Grain yield/ plant (g.)	Straw yield/ plant (g.)
Line 14	117.20	150.17	82.71	5.92	22.32	89.42	41.50	25.13	84.10
Line 22	138.42	177.36	96.80	6.56	22.32	100.42	50.16	23.20	70.74
Line 23	130.63	167.38	102.02	6.43	23.60	106.19	50.80	24.52	79.65
Line 29	123.79	158.62	85.25	6.59	15.51	89.78	55.47	22.25	62.06
Line 30	132.36	169.60	97.43	6.42	18.85	84.81	51.85	23.41	72.82
Line 31	140.15	179.58	88.00	6.73	22.20	99.88	44.55	24.72	76.29
Line 32	127.17	162.95	92.27	6.90	25.01	112.56	48.49	23.85	67.09
Line 33	137.12	175.70	96.77	6.93	26.11	117.49	48.56	29.40	94.40
Line 34	131.06	167.94	86.84	6.96	24.42	109.89	48.48	24.46	77.07
Line 35	136.56	174.98	106.45	7.22	19.33	86.99	60.85	23.68	68.28
Line 52	105.36	139.06	76.58	5.48	20.70	93.15	38.50	23.24	77.82
Line 60	118.57	156.50	85.42	5.81	19.62	85.31	44.24	23.10	67.20
Line 69	120.06	158.45	77.64	5.94	19.58	88.10	40.30	21.16	60.37
Line 71	117.46	155.03	85.37	6.11	23.08	103.84	42.92	27.91	90.75
Line 90	107.06	141.30	77.81	5.57	21.03	94.64	38.12	23.32	79.07
Line 98	126.44	166.88	91.09	6.20	20.93	97.17	47.18	24.63	66.51
Line 99	119.33	157.49	96.00	6.06	22.17	99.75	47.84	23.03	70.81
Line 107	128.02	168.97	82.79	6.33	20.88	93.94	41.91	24.16	71.66
Line 108	116.17	153.32	86.84	6.50	23.55	105.95	45.67	23.34	63.00
Line 109	125.26	165.32	91.04	6.52	24.61	110.53	45.77	27.63	92.51
Line 128	102.20	134.89	74.28	5.32	20.08	90.35	37.35	23.55	75.48
Line 136	115.02	151.80	82.86	5.64	19.04	85.66	42.91	21.41	60.50
Line 147	113.94	150.38	82.81	5.93	22.38	100.93	41.63	27.95	84.15
Line 155	114.65	151.32	82.60	5.62	18.98	85.39	42.78	23.32	64.30
Line 166	113.58	149.90	82.55	5.91	22.31	100.41	41.50	25.06	83.89
Mean	122.30	159.40	87.61	6.22	21.54	96.94	45.57	24.30	74.42
Over all mean	110.90	145.33	81.15	5.41	17.13	77.09	44.86	19.15	57.60
L.S.D.0.05									
G	3.88	2.74	5.49	1.63	1.58	2.31	5.23	3.82	7.39
S	0.72	0.54	1.04	0.78	0.61	1.10	25.52	18.49	36.09
S× G	27.09	16.31	38.32	69.54	34.82	103.67	0.45	0.32	0.63

Phenotypic correlation:

The relationship between any two traits plays an important role in breeding programs. Sperman correlation coefficient values among all studied traits in combined across seasons and under Izraa and kafrdan conditions are presented in Tables (6 and 7). Positive and significant correlation was found between; days to heading (50%) with both maturity date (0.890** and 0.993**) and plant height (0.713** and 0.772**) under both sites, respectively and across seasons. As well as no. of spikes/plant and 1000-kernel weight (0.618**) under kafrdan conditions, maturity date with plant height (0.720** and 0.772**) in both sites, respectively and across seasons and between each of no. of spikes/plant and 1000-kernel weight (**0.618**)** under kafrdan conditions, plant height with both 1000-grain weight (0.728** and 0.768**) and straw yield/plant (0.882** and 0.636**) under both sites, respectively, no. of spikes/plant with no. of grains/spike , grain yield/plant and straw yield/plant under both sites and across seasons in addition to no. of sikelets/spike (0.580**) and 1000-kernel weight (0.615**) under kafrdan conditions, no. of sikelets/spike with no. of grains/spike (0.927** and 0.941**), grain yield/plant and straw yield/plant (0.907** and 0.912**) in both sites, respectively, no. of grains/spike with grain yield/plant (0.696** and 0.744**) and straw yield/plant (0.719** and 0.773**) under Izraa and kafrdan conditions, respectively, 1000-kernel weight with each of grain yield/plant (0.681** and 0.556**) as well as between grain yield/plant and straw yield/plant (0.907** and 0.912**) across seasons and the two sites, respectively.

The obtained results of correlation analysis useful to determination effective traits correlated with grain yield in indirect selection procedures for superior genotypes and were in agreement with those findings by **Beheshtizadeh *et al* (2013) and Fouad (2020).**

Table 6. Sperman Coefficients of phenotypic correlation for combined data across seasons for the studied traits under Izraa conditions.

Traits	(X_1)	(X_2)	(X_3)	(X_4)	(X_5)	(X_6)	(X_7)	(X_8)
Days to heading (50%) (X_1)	1.000							
Maturity date (X_2)	0.890**	1.000						
Plant height (X_3)	0.713**	0.720**	1.000					
No. of spikes/plant (X_4)	0.519	0.549	0.495	1.000				
No. of sikelets/spike (X_5)	0.464	0.482	0.220	0.526	1.000			
No. of grains/spike (X_6)	0.528	0.501	0.209	0.641**	0.927**	1.000		
1000-kernel weight (X_7)	0.551	0.544	0.728**	0.353	-0.242	-0.265	1.000	
Grain yield/plant (X_8)	0.500	0.512	0.404	0.894**	0.723**	0.696**	0.681**	1.000
Straw yield/plant (X_9)	0.469	0.493	0.882**	0.757**	0.757**	0.719**	0.415	0.907**

*, ** denote significance at 0.05 and 0.01 probability levels, respectively.

Table 7. Sperman Coefficients of phenotypic correlation for combined data across seasons for the studied traits under Kafrdan conditions.

Traits	(X_1)	(X_2)	(X_3)	(X_4)	(X_5)	(X_6)	(X_7)	(X_8)
Days to heading (50%) (X_1)	1.000							
Maturity date (X_2)	0.993**	1.000						
Plant height (X_3)	0.772**	0.772**	1.000					
No. of spikes/plant (X_4)	0.684**	0.575**	0.555	1.000				
No. of sikelets/spike (X_5)	0.537	0.486	0.296	0.580**	1.000			
No. of grains/spike (X_6)	0.433	0.521	0.376	0.631**	0.941**	1.000		
1000-kernel weight (X_7)	0.621**	0.618**	0.768**	0.615**	-0.125	-0.125	1.000	
Grain yield/plant (X_8)	0.513	0.485	0.460	0.901**	0.744**	0.744**	0.556**	1.000
Straw yield/plant (X_9)	0.406	0.512	0.636**	0.772**	0.853**	0.773**	0.093	0.912**

*, ** denote significance at 0.05 and 0.01 probability levels, respectively.

Principal component (PCA) and Biplot analysis:

Principal component and biplot analysis was performed for all traits under study (Table 8 and Fig.1). PCA showed a high level of variability among the genotypes and allowed the division of the collection data for different studied traits of genotypes performance into two groups corresponding (components). The two components could justify more than 80% under both sites of the whole variance in the original data. The first component could justify amount of the variance among genotypes for different traits (58.70% and 60.98% under Izraa and kafrdan conditions, respectively), while, the second component could justify more than 25.04% under Izraa and 23.61% under kafrdan with total cumulative percentage of the whole variance (83.74% and 84.59% under Izraa and kafrdan, respectively) in the original data. Rotate component matrix showed that days to heading (50%), maturity data, number of spikelets/spike, number of grains/spike, grain yield/plant and straw yield/plant under both sites were in the first group (component1) and plant height and 1000-kernel weight were in the second group (component2).

These findings were confirmed by factor loadings for 9 studied traits of these two Principal component analysis which plotted on Fig. 1 to display the relationship between the 168 genotypes and their traits. The vectors of trait revealed angles between studied traits, angles < 90° refer to a positive correlation between traits, while angles > 90° refer to a negative correlation. Further, angles near 0° and 180° refer to increase in association intensity. Moreover, length of trait vector indicates the extent of variation caused by this trait in PCA. It can be concluded that the traits of each group are correlated. Similar findings were obtained by Beheshtizadeh *et al.* (2013), Boshev *et al.* (2016) and Fouad (2020).

Table 8. The principal component analysis in combined data across seasons for different studied traits under Izraa and Kafrdan conditions .

Site	Component[1]	Eigen Value[2]	Cumulative percentage	Days to heading (50%)	Maturity date	Plant height	No. of spikelets/ spike	No. of spikes/ plant	No. of grains/ spike	1000-kernel weight	Grain yield/ plant	Straw yield/ plant
Izraa	**1**	**5.28**	**58.70**	**0.827**	**0.835**	**0.661**	**0.843**	**0.770**	**0.806**	**0.305**	**0.869**	**0.857**
	2	**2.25**	**25.04**	**0.406**	**0.380**	**0.603**	**-0.022**	**-0.537**	**-0.492**	**0.902**	**-0.278**	**-0.301**
Kafrda	**1**	**5.49**	**60.98**	**0.846**	**0.857**	**0.699**	**0.850**	**0.775**	**0.891**	**0.389**	**0.853**	**0.825**
	2	**2.13**	**23.61**	**0.380**	**0.377**	**0.568**	**-0.032**	**-0.533**	**-0.450**	**0.873**	**-0.285**	**-0.423**

[1]Component: the axis which explained variance by the k-dimensional ordination.
[2]Eigenvalue: the variance explained by the k-dimensional ordination.

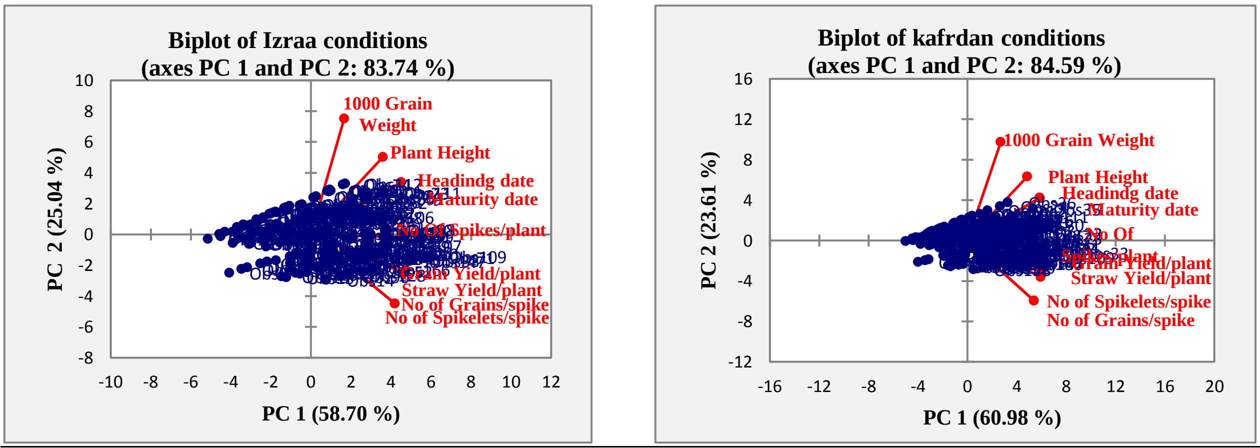

Figure 1. Biplot graphical display of the measured traits in bread wheat cultivars under Izraa and kafrdan conditions.

Genetic divergence and Cluster analysis:

Cluster analysis of Euclidean distances, based on studied traits revealed a high degree of genetic divergence in the present set of genotypes under Izraa and Kafrdan were carried out (Tables 9 and 10) and (Figure 2 and 3). Dendrogram classified the 168 lines into four main clusters if the cutting is done on the distance 13 under both sites. While, 15 intra cluster under Izraa and 10 intra cluster under Kafrdan. Amongst these clusters accompanied with hierarchical Euclidean cluster analysis, the first (I) and second (II) clusters was the largest and contained 24 and 20 genotypes (14.28% and 11.90% of total genotypes, respectively) under Izraa as well as the first (I), second (II), third (III) and fourth (IV) clusters recorded the highest number of sets; 19, 22, 33 and 25 genotypes (11.31, 13.09, 19.64 % and 14.88% of total genotypes, respectively) under Kafrdan which exhibited high degree of genetic diversity and may be helpful in further wheat breeding and selection programs. The minimum intra cluster distance was observed within clusters XIII, XIV and XV under Izraa in addition to clusters VI, VII, IX and X under kafrdan (Table 9 and 10), which exhibited less genetic diversity and thus may be utilized under population improvement of bread wheat genotypes. Similar findings was obtained by Kabir *et al.* (2017), Kandel *et al.* (2018), Santosh *et al*. (2019) and Fouad (2020) They concluded that the selected genotypes bearing the desired values from clusters which had significant genetic distance could be used in hybridization to obtain new genetic recombination's and transgressive segregation in future breeding program, which aimed to improvement higher yielding wheat genotypes under environmental conditions.

Table 9. Distribution and grouping of 168 bread wheat genotypes into different diversity classes based on Euclidean distances analysis under Izraa conditions.

Cluster	Number of genotypes	Name of Lines	Proportions (%)
I	24	20, 25, 27, 28, 29, 55, 56, 57, 58, 63, 65, 66, 67, 96, 101, 103, 104, 105, 132, 134, 139, 141, 142, 143.	14.28
II	20	21, 24, 30, 26,54, 59, 62, 64, 68, 70, 97, 100, 102, 106, 108, 135, 138, 140, 144, 168.	11.90
III	10	61, 69, 72, 74, 75, 99, 107, 110, 112, 113.	5.96
IV	10	32, 37, 60, 71, 73, 97, 109, 111, 146, 151.	5.96
V	10	23, 31, 34, 36, 38, 145, 137, 148, 150, 152.	5.96
VI	10	22, 33, 35, 77, 85, 115, 123, 136, 147, 149.	5.96
VII	10	78, 82, 83, 84, 86, 116,120, 121, 122, 124.	5.96
VIII	10	81, 87, 89, 91, 93, 119, 125, 127, 129, 131.	5.96
IX	11	18, 47, 79, 80, 88, 95, 117, 118, 126, 133, 161.	6.54
X	12	17, 19, 39, 46, 48, 90, 92, 129, 130, 153, 160, 162.	7.14
XI	11	16, 40, 43, 44, 45, 49, 154, 157, 158, 159, 163 .	6.54
XII	10	41, 42, 50, 51, 53, 155, 156, 164, 165, 167.	5.95
XIII	6	3, 4, 12, 14, 52, 166.	3.57
XIV	5	13, 15, 76, 94,114.	2.97
XV	9	1, 2, 5, 6, 7, 8, 9, 10, 11.	5.35

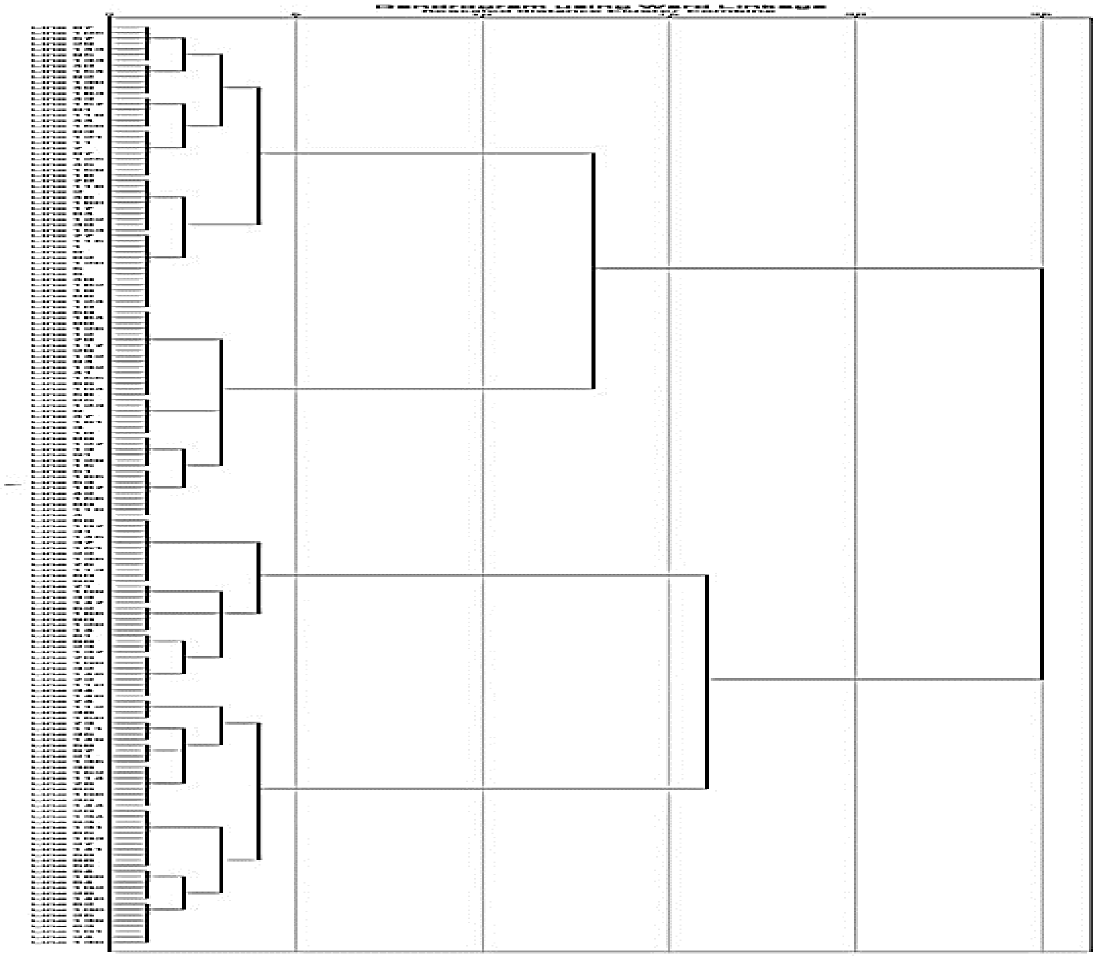

Figure 2. Dendrogram of bread wheat genotypes based on Ward's method based and squared Euclidian distance for studied traits under Izraa rainfed conditions.

Table 10. Distribution and grouping of 168 bread wheat genotypes into different diversity classes based on Euclidean distances analysis under Kafrdan conditions.

Cluster	Number of genotypes	Name of Lines	Proportions (%)
I	19	1, 8, 39, 40, 46, 55, 58, 65, 77, 78, 84, 93, 116, 122, 131, 134, 141, 153, 160.	11.31
II	22	9,41, 42, 50, 51, 53, 56, 66, 79, 80, 88, 89, 91, 94, 117, 118, 126, 127, 129, 132, 142, 161.	13.09
III	33	2, 5, 6, 7, 10, 11, 49, 54, 57, 59, 62, 63, 64, 67, 83, 87, 92, 95, 114, 130, 133, 135, 138, 139, 140, 143, 144, 154, 157, 158, 159, 162, 163.	19.64
IV	25	3, 4, 12, 13, 15, 18, 28, 60, 61, 69, 70, 72, 75, 104, 136, 137, 145, 146, 148, 151, 155, 156, 164, 165, 167.	14.88
V	14	16, 19, 29, 38, 73, 76, 68, 101, 102, 105, 106, 149, 152, 168.	8.33
VI	6	14, 52, 71, 90, 147, 166.	3.57
VII	10	17, 20, 27, 47, 74, 85, 96, 103, 123, 150.	5.95
VIII	17	26, 24, 25, 30, 43, 44, 45, 48, 81, 82, 86, 111, 119, 120, 121, 124, 125	10.11
IX	11	22, 31, 32, 34, 37, 98, 99, 107, 108, 110, 113.	6.56
X	11	21, 23, 33, 35, 36, 97, 100, 109, 112, 115, 128.	6.56

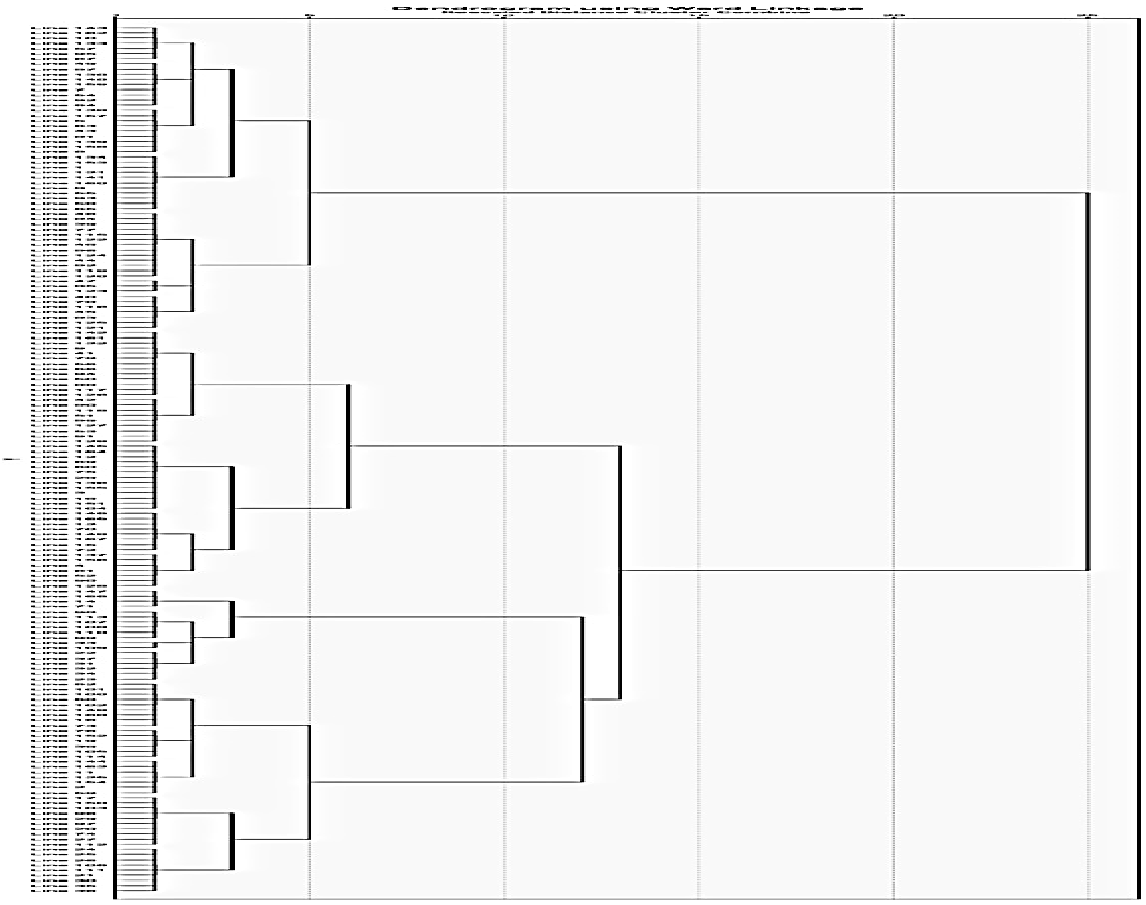

Figure 3. Dendrogram of bread wheat genotypes using Ward’s method based on Euclidian distance for studied traits under Kafrdan rainfed conditions

Conclusion

It could be concluded that the most traits highly contributing in variation of principal component were no. of spikes/plant, no. of sikelets/spike, no. of grains/spike and 1000-kernel weight had the major components for grain yield/plant and should be considered in selection programs for yield potentiality improvement of promising bread wheat genotypes under aid and semi-arid conditions. The maximum intra-cluster distance was observed between first (I) and second (II) clusters under Izraa as well as the first (I), second (II), third (III) and fourth (IV) clusters recorded the highest number of sets, furthermore, hybridization between genotypes in different sets could give new recombination and transgressive segregations in the progenies derived from their crossing

Also, the new high yielding bred lines; 33, 71, 109 and 147 have more adaptability for rainfed under Izraa and Kafrdan conditions, which could be used for distributed to farmers and/or in future breeding programs to develop high yielding genotypes. From the above results, it is clear, in a large extent, that magnitude of increasing grain yield/plant is associated with yielding potentiality of genotype, suggesting that selection would be effective in developing desired genotypes combining high yield with more tolerance under rainfed conditions.

Recommendation

It is highly recommended to use the four promising bred lines; 33, 71, 109 and 147 in bread wheat breeding programs to ensure the trasngressive segregants genotypes in the following generations and/or distributed to farmers under Izraa and Kafrdan conditions. Also, indirect selection via traits no. of spikes/plant, no. of grains/spike and 1000-grain weight which have highly contribution relative to grain yield is emphasized in this study for genetic improvement of plant yield under rainfed conditions. These new early maturing and improved genotypes considered to be used as parents in future breeding programs or distributed to the targeted farmers.

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