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COMPARATIVE EFFICIENCY OF BREEDING METHODS FOR SELECTION OF IMPROVED HIGH-YIELDING GENOTYPES OF BARLEY UNDER SEMIARID REGIONS

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ABSTRACT

Barley breeders need to achieve the aim of developing genotypes that will maximize yield under unfavorable conditions which could be realized through selection for broad and specific adaptation by using different breeding methods to develop superior cultivars. This investigation was initiated to assess the effectiveness of four selection methods, i.e. bulk selection method (BM), modified bulk selection method (MBM), pedigree selection method (PM)and single seed descent selection method (SSDM) applied in the early segregating generations of 10 diverse six-rowed barley crosses to improve yield and its components. The six-rowed barley selected populations were grown under two different rainfed conditions at Izraa Agricultural Experiment Station of ACSAD, Daraa governorate, Syria and Kafrdan Agricultural Experiment Station of ACSAD, Beqaa governorate, Lebanon for three successive seasons (2016/17, 2017/18 and 2018/19) to compare the efficiency of four selection methods. Results of analysis of variance and combined analysis showed significant and/or highly significant differences among lines derived from the ten populations and the four methods of selection for all studied traits and the interaction between selection methods x genotypes were highly significant for all studied traits. Mean performance of selected genotypes for the two selection methods SSDM and PM recorded the highest values in the ten populations and were significantly superior to BM and MBM methods. MBM and the SSDM recorded the highest values of phenotypic variance (σ^2p) and genotypic variance (σ^2g), respectively, for all studied traits as well as phenotypic variance in SSDM for no. of grains/spike, 1000 grain weight, grain yield/plant and straw yield/plant under both locations in addition to plant height and no. of spikes/plant under Kafrdan conditions. While, Broad sense heritability estimates ranged from intermediate to high according to selection method and population in all studied traits. Meanwhile, values of genetic advance and genetic gain were lower in the two methods of selection BM and MBM compared to those of PM and SSDM for all traits under Izraa and Kafrdan conditions. Results indicated that visual selection for yield by PM and/or SSDM seemed to be an effective under both locations than the other two methods and selected promising lines from the three populations 3, 5 and 7 at early generation for testing in barley could led to improved higher yielding and more tolerant lines under semiarid conditions.

Key words: ***Barley, Hordeum vulgare* L.*, Selection methods, Yield and its component, Broad sense heritability, PCV, GCV, Genetic gain, Rainfed conditions*.**

INRRODUCTION

Barley (*Hordeum vulgare* L.) was one of the first domesticated crops and has been used as a regular source of food, being part of several links in the food industry, major raw material for malting and brewing industries (Cattivell *et al* 1994) and occupies the fourth position in area and the third position in crop production. Also, barley is widely grown under arid and semi-arid regions in the world which produced 140.6 million MT in 2018/19 (Statista 2019). The Arab world production reached 7.6 million MT which mainly produced under rainfed areas and in the newly reclaimed saline soil lands, the following Arab countries produce the most of barley production, Algeria, Syria, Iraq, Morocco, Tunisia and Egypt (2.05, 2.0, 1.6, 1.0 and 0.108 million MT, respectively) in 2018/19 (World Agricultural Production 2019).

Breeding for drought resistance based on direct selection for grain yield in the target environment (empirical or pragmatic breeding) appears to be the most obvious solution. Several selection methods were used to select adapted material with desirable properties. This approach faces two major problems; first one, the precision of the yield trials conducted under drought conditions, and secondly, the existence of several target environments, each characterized by its own specific type of drought and combination of stress (Ceccarelli and Grando 2002). Quantitative genetic inheritance for yield provides much of the frame work for the design and analysis of selection methods used within breeding programs (Falconer and Mackay 1996, Allard 1999, Cooper *et al* 1999 and Sayd *et al* 2019). Various methods are used to obtain high performing inbred lines in the breeding of self-pollinated crops. Selection can be applied in different stages of the breeding process and with varying intensities Van Oeveren (1993). Breeding methods play a major role in developing high yielding cultivars under biotic and abiotic stresses causing reductions in crop yield, particularly in new reclaimed area (Greveniotis *et al* 2018). When the breeding program serves a target population of very diverse environments, where genotype by environment interactions are expected to be large, selection should be for specific adaptation (Ceccarelli 1996).

Genetic improvement of crops can be considered as directed evaluation acting on the existing genetic variability in the germplasm. Improvement of grain yield can be done by direct selection on single plant basis in early generation or field plot basis in late generations. So, the breeders need information about nature of gene action, heritability, inbreeding depression, heterosis and predicted genetic gain from selection (Δg) for yield and yield components (Habouh 2019). Observed differences in response to phenotypic selection based on selection methods depending on the traits and cross involved (Turcotte *et al* 1980). Although bulks selection method of heads will generate families with head-rows, homozygosity needs much more time as compared to the bulk, Pedigree and single seed descent selection (SSD) methods, where selection is shortly operated from the F_5; however, early selection was practiced to speed-up the breeding program (Medimagh *et al* 2012). The consistent difficulties observed in the breeding work are indicated to separate the additive from the non-additive effects in F_2 generation (EL-Refaey *et al* 2015). As such, yield performances might be investigated from the F_3 (Shakoor, 1983). Hence, consideration of quantitative approaches for exploitation of the genetic variability and estimates of genetic parameters serve as a base for selection of genotypes and hybridization since degree of variability for a given character is a basic prerequisite for its improvement (Necdet Akgun 2016). Ghimire and Mahat 2019 and Yadav *et al* 2019 found that broad sense heritability values varied under stress conditions from intermediate to high accompanied with high genetic advance for grain yield and its components in barley.

This investigation was initiated to assess the effectiveness of four selection procedures, i.e., pedigree selection (PS), bulk selection (BS), single seed descent selection (SSD) and modified bulk selection (MBS) applied in the early segregating generations (F_2, F_3 and F_4) of 10 barley crosses to improve yield and its components of diverse population under semiarid regions.

MATERIALS AND METHODS

This study was carried out during the three successive seasons, i. e., 2015/2016, 2016/2017 and 2017/2018, under rainfed conditions at two regions; Izraa Agricultural Experiment Station of ACSAD, Daraa governorate, Syria (32.8449° N, 36.2251° E) semi-dry location and kafrdan Agricultural Experiment Station of ACSAD, Bekaa governorate, Lebanon (34.017° N, 36.050° E) sub-humid location. Bulk method (BM), Modified bulk method (MBM), Pedigree method (PM) and single seed descent method (SSDM) were practiced in 18 six raw barley populations produced from 10 crosses which were chosen from six raw barley breeding program at ACSAD based on their genetic diversity and performance under field conditions. The pedigrees of the parents of the 18 barley populations are given in (Table 1).

Table 1. The pedigree, source and origin of the parental genotypes (G.) of the 10 barley populations.

G.	Source	Pedigree and/or selection history	G.	Source	Pedigree and/or selection history
Population 1			Population 2		
Line-1	ACSAD	ACSAD1644	Line-1	ACSAD	ACSAD1644
Line-2	ICARDA	ALANDA/HAMRA/3/AW BLACK/ATHS//RHN-08	Line-3	ICARDA	BARBARA/4/BACA ”S”/3/AC253//C108887/C105761/5/BARBARA/4/BACA’S’/3/AC253
Population 3			Population 4		
Line-4	ICARDA	BUCK M8.88/E.ACACIA//MSEL	Line-5	ACSAD	ACSAD 1632
Line-1	ACSAD	ACSAD1644	Line-6	ACSAD	ACSAD 1640
Population 5			Population 6		
Line-7	ACSAD	ACSAD 1630	Line-1	ACSAD	ACSAD 1644
Line-8	ICARDA	RHN-03/6/80-5132/4/BERA′S′/CEL// OKSAMUT/3/ ORE′S′/5/ GLORIA′S′/ COPAL′S′LIGNEE 640 /7/ ARIZONA5908/ ATHS// AVT /ATTIKI /3/S.TBARLEY /4/ATHS/ LIGNEE 686	Line-9	ICARDA	ETHIRA/B/69-2
Population 7			Population 8		
Line-5	ACSAD	ACSAD 1632	Line-10	ACSAD	ACSAD 1700
Line-6	ICARDA	9C7-1	Line-11	ICARDA	LITANI/MUNDAH
Population 9			Population 10		
Line-12	ACSAD	ACSAD 1460	Line-27	ICARDA	IPA 7
Line-13	ICARDA	9C7-1	Line-28	ACSAD	NK1272 / JLB70 -63

ICARDA; International Center of Agricultural Research in the Dry Areas, Syria.
ACSAD; Arab Center for the Studies of Arid Zones and Dry Lands, Syria.

Sowing date was 15, 13 and 18 November in the three seasons, respectively, while plot area was of 5 x 5 m. The recommended dose of phosphatic fertilizer at rate (50 kg P_2O_5/fed) was added during seed bed preparation, whereas nitrogen fertilizer at rate of 60 kg N/fed was applied as ammonium sulfate (20.5% N) where 1/3 of the amount was incorporated in dry soil before sowing, 1/3 was added one week before panicle initiation growth stage 18 and the rest was added at grain filling period growth stage 50 of Zadoks' scale (Zadok *et al* 1974).

Meteorological data presented in Table (2) show that the temperature, relative humidity, solar radiation and amount of rainfall every 10 days in both seasons. However the precipitated rain amount reached 163.45, 181.60 and 215.45mm under the first site and 427.80, 475.33, and 590.51mm in the three seasons, respectively.

Table 2. Monthly average weather data at the two sites Izraa and kafrdan during three growing seasons 2016/17, 2017/18 and 2018/19.

Site	Month	Season (2016-2017)			Season (2017-2018)			Season (2018-2019)		
		T.† (C°)		Amount Rainfall (mm)	T.† (C°)		Amount Rainfall (mm)	T.† (C°)		Amount Rainfall (mm)
		Max.	Min.		Max.	Min.		Max.	Min.	
Izraa	November	21.42	11.34	2.08	23.80	12.60	2.31	21.64	11.70	4.17
	December	15.40	8.87	6.30	17.11	9.86	7.00	16.90	10.28	11.00
	January	11.14	6.08	34.68	13.10	7.15	40.80	11.25	8.14	35.00
	February	13.15	4.59	35.70	15.47	5.40	42.00	14.19	3.22	67.28
	March	19.30	5.87	2.55	22.70	6.90	3.00	18.63	5.81	45.00
	April	22.07	8.93	12.75	25.96	10.50	15.00	23.62	11.15	34.00
	May	25.95	11.86	64.35	28.83	13.18	71.50	29.44	15.09	19.00
	June	32.51	15.61	0.00	36.12	17.34	0.00	35.65	18.70	0.00
	Mean	20.60	9.33	Tot. =163.45	22.89	10.37	Tot. =181.60	21.41	10.51	Tot. =215.45
Kafrdan	November	27.85	13.61	6.24	30.94	15.12	6.93	25.97	14.04	12.51
	December	18.90	10.06	17.85	22.24	11.832	21	20.28	12.34	33.00
	January	14.48	7.29	104.04	17.03	8.58	122.4	13.50	9.77	105.00
	February	17.09	5.51	107.10	20.11	6.48	126	17.03	3.86	187.00
	March	25.08	7.04	7.65	29.51	8.28	9	22.36	6.97	94.00
	April	30.38	11.34	40.50	33.75	12.6	45	28.34	13.38	102.00
	May	33.73	14.23	130.50	37.48	15.816	145	35.33	18.11	57.00
	June	42.26	18.73	0.00	46.96	20.808	0	42.78	22.44	0.00
	Mean	26.78	11.20	Tot. =427.80	29.75	12.44	Tot. = 475.33	25.70	12.61	Tot. =590.51

†T. = Temperature

In the 1st season, 2000 plants were selected from F_2 in each site and were grown in non replicated plots of each F_3 population. Each plot consists of 15 rows, 5 m long, 30 cm apart and 10 cm between plants within rows. Lodged, unprotected and bird damaged plants were discarded. At maturity, plants were individually harvested and threshed. Data were collected on 800 harvested plants of each population. The selection was practiced twice in season, at heading and at maturity stages and intensity was 10% for yield and its components and 80 plants were selected and subjected to the four breeding methods in the two sites.

In the Bulk method (BM) method, the remaining unselected F_3 plants, plus the remaining grains from the selected F_3 plants were mixed to form the population seed bulk for each population. A random sample of mixed grains was space-planted as F_4 generation during 2017/18 season. Grains of each population plants were kept separately to be raised as F_5 generation in the final evaluated trail during 2018/19. While, in the modified bulk method (MBM) method, one spike from each selected F_3 plant from each population was bulk harvested and threshed to form the population seed bulk. A random sample of bulked seed of each population was space-planted as F_4 generation during the 2nd season. Selection was practiced on the basis of 60 plants per each population. Grains of each selected plants were kept separately to be raised as F_5 generation.

For pedigree method (PM), each of selected 80 plants in F_3 for each population was sown in a separate row as F_4 families during 2017/18 season in randomized complete design with three replications in the two sites. Selection between and within families was practiced. 10 families and the best plant within each selected family were selected from each population to be raised as F_5 families in the final evaluation trial during 2018/19. Further, in the single seed descent method (SSDM), one grain was taken from 800 plants from F_2 population and planted during 2016/2017 season as F_3 generations. One grain was taken from each plant to be grown as F_4 generations during the growing season of 2017/2018. Similarly, 60 plants were selected from each population and were harvested individually. Grains from each plant were kept and planted separately as F_5 plants during 2018/2019 season.

In the 3rd season, sixty F_5 lines for each population and each selection method were sown in a randomized complete block design with three replications. Each plot was represented by one row; a row was 5 m long, 30 cm apart and 10 cm between hills within row. At maturity 60 guarded plants were selected and the following data were recorded; Number of days to heading and maturity (days), plant height (cm), number of spikes/plant, number of spikletes/spike, number of grains/spike, 1000 grain weight (g), grain yield/plant (g) and straw yield/plant (g) for each genotype.

Data for mean of 60 plants of ten crosses for each population and each method were subjected to analysis of variance by GenStat- 7th ed. (GenStat 2004) computer program in randomized complete blocks design (RCBD) to compute the genetic parameters and variability in each method according to Snedecor and Cochran (1989). The combined analysis was performed among methods and the least significant difference (L.S.D) test at 5% level of probability was used to compare among means. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated using the following formula as suggested by Burton (1952).

GCV= $\sqrt{\sigma^2 g} \ / \bar{x}) * 10$and PCV = $(\sqrt{\sigma^2 ph} \ / \bar{x}) * 100$

(Where, σ^2_g, σ^2_{ph} are the genotypic and phenotypic variances, respectively and × = lines mean performance of each trait)

Heritability was estimated in broad sense by using following formula as suggested by Lush (1940). Heritability in broad sense (h_b^2) = $\sigma^2 g$ / σ^2 p*100, while genetic gain (GG) was percent expected genetic advance over the population mean. It was computed using the formula of Johnson *et al* (1955) GG= (GA/×) *100.

RESULTS AND DISCUSSION

Analysis of variance

The analysis of variance (ANOVA) and combined analysis for the 60 F_5 six raw barley lines derived from the ten populations and the four selection methods under the two locations are presented in Tables 3 and 4. Mean squares were significant and/or highly significant for the four selection methods (S.M.), lines (L.) derived from each population and interaction S.M. × L. for all traits under study, indicating to the variability that existed among populations, the presence of wide diversity among lines and their different responses to method of selection. Similar results were found by Choo *et al* (1980), Medimagh *et al* (2012), Greveniotis *et al* (2018), Habouh (2019), Ghimire and Mahat (2019) and Neyhart *et al* (2019).

Table 3. Mean squares due to barley Lines (L.) in 10 populations (P.) for different studied traits across four selection methods (S.M.) under Izraa conditions.

Population	SOV	df	Mean squares								
			Days to 50% heading	Days to 50% maturity	Plant height (cm)	No of spikes/ plant	No of spikelets/ spike	No of grains/ spike	1000 grain weight (g)	Grain yield/Plant (g)	Straw yield /plant (g)
Population 1	R	2	129.51**	218.70**	69.60**	0.15**	2.13**	19.11**	22.68**	0.18**	2.01**
	S.M.	3	6958.75**	11729.10**	3587.50**	7.40**	115.90**	1000.55**	1129.05**	8.35**	103.80**
	L.	59	315.53**	532.53**	79.30**	0.12**	2.36**	21.71**	25.49**	0.21*	98.18**
	S.M.× L.	177	100.53**	200.83**	210.12**	1.10**	5.00**	42.05**	100.05**	2.01**	6.12**
	Error	531	50.68	85.54	27.24	0.06	0.81	7.39	8.89	0.07	0.69
Population 2	R	2	144.54**	244.53**	73.89**	0.27**	2.49**	22.41**	24.06**	0.27**	2.43**
	S.M.	3	7237.90**	12142.95**	3876.10**	12.65**	131.00**	1177.20**	1254.75**	12.10**	109.95**
	L.	59	711.30**	1202.77**	97.00**	0.24**	2.93**	26.20**	28.20**	0.24**	34.93**
	S.M.× L.	177	541.18**	1002.01**	100.12**	3.00**	2.00**	30.04**	40.04**	3.00**	20.06**
	Error	531	56.79	96.16	28.97	0.11	0.98	8.82	9.45	0.11	0.95
Population 3	R	2	158.13**	267.18**	79.86**	0.47**	3.30**	29.79**	20.61**	0.45**	3.27**
	S.M.	3	8404.10**	14175.70**	4098.15**	23.00**	176.15**	1581.85**	1059.95**	20.24**	156.26**
	L.	59	421.94**	631.90**	85.67**	2.50**	3.53**	31.86**	22.07**	2.48**	110.42**
	S.M.× L.	177	170.83**	401.30**	200.14**	0.21*	2.01**	20.05**	50.04**	2.00**	50.24**
	Error	531	62.21	105.05	31.40	0.18	1.29	11.71	8.08	0.17	1.27
Population 4	R	2	140.76**	237.93**	88.95**	0.39**	4.20**	37.80**	23.12**	0.36**	3.86**
	S.M.	3	7074.05**	11801.60**	4088.55**	18.85**	216.17**	1833.05**	1225.80**	19.18**	208.08**
	L.	59	834.51**	1347.56**	837.83**	1.42**	9.58**	141.35**	25.29**	0.40**	138.62**
	S.M.× L.	177	701.72**	502.95**	761.49**	1.00**	5.01**	100.07**	20.04**	0.30**	50.32**
	Error	531	55.29	93.62	34.98	0.15	1.65	14.86	9.07	0.14	1.52
Population 5	R	2	139.86**	236.42**	89.88**	0.27**	2.07**	18.65**	26.46**	0.29**	2.45**
	S.M.	3	7425.55**	12518.49**	4730.97**	14.74**	110.55**	995.49**	1403.90**	15.13**	125.89**
	L.	59	193.27**	190.82**	155.22**	0.32**	2.42**	21.84**	31.03**	0.33**	35.52**
	S.M.× L.	177	100.32**	100.55**	50.17*	0.20**	1.20*	10.04**	20.05**	0.20*	6.06**
	Error	531	54.95	92.95	35.33	0.11	0.81	7.33	10.40	0.10	0.96

Table 3. Cont.

Population	SOV	df	Mean squares								
			Days to 50% heading	Days to 50% maturity	Plant height (cm)	No of spikes/ plant	No of spikelets/ spike	No of grains/ spike	1000 grain weight (g)	Grain yield/Plant (g)	Straw yield /plant (g)
Population 6	R	2	131.50**	222.24**	79.76**	0.41**	2.00**	17.96**	23.44**	0.36**	2.67**
	S.M.	3	6637.23**	11159.57**	4039.18**	31.82**	104.32**	936.19**	1186.14**	23.85**	158.13**
	L.	59	722.43**	1220.36**	158.16**	3.95**	2.48**	22.34**	47.44**	1.59**	91.10**
	S.M.× L.	177	225.78**	443.47**	60.99**	3.50**	1.13**	11.16**	18.91**	1.18**	2.81**
	Error	531	51.73	87.38	31.35	0.16	0.78	7.06	9.21	0.14	1.05
Population 7	R	2	127.28**	214.87**	78.94**	0.44**	2.44**	22.06**	23.82**	0.54**	3.58**
	S.M.	3	6641.06**	11262.23**	4205.41**	23.15**	130.59**	1176.16**	1259.15**	17.00**	182.05**
	L.	59	1019.61**	1723.76**	92.52**	1.02**	2.84**	25.88**	27.90**	0.88**	170.24**
	S.M.× L.	177	201.73**	302.88**	40.15*	0.50**	1.00*	10.04**	20.05**	0.30**	10.27**
	Error	531	50.08	84.54	31.03	0.17	0.96	8.67	9.36	0.13	1.41
Population 8	R	2	141.79**	239.75**	70.21**	0.22**	2.17**	19.62**	23.44**	0.19**	2.04**
	S.M.	3	7525.46**	12687.33**	3721.48**	11.43**	115.46**	1047.73**	1241.94**	10.24**	109.04**
	L.	59	1128.33**	1907.65**	82.28**	0.26**	2.56**	22.99**	27.45**	0.23**	97.52**
	S.M.× L.	177	101.90**	203.20**	50.14**	0.10*	2.00**	10.04**	20.05**	0.10**	1.17**
	Error	531	55.79	94.32	27.61	0.08	0.85	7.71	9.22	0.07	0.80
Population 9	R	2	125.49**	212.03**	57.67**	0.36**	2.63**	23.63**	16.40**	0.76**	7.26**
	S.M.	3	6646.31**	11302.49**	3101.57**	13.09**	139.28**	1260.26**	872.97**	12.10**	111.31**
	L.	59	271.58**	458.88**	116.31**	0.72**	7.60**	68.09**	47.20**	1.74**	20.78**
	S.M.× L.	177	100.46**	100.78**	50.27**	0.30**	2.01**	11.11**	10.08**	0.50**	5.03**
	Error	531	49.35	83.37	22.67	0.10	1.03	9.29	6.44	0.10	0.89
Population 10	R	2	126.72**	214.04**	64.55**	0.63**	2.03**	18.26**	26.21**	0.37**	3.67**
	S.M.	3	6712.06**	11414.83**	3432.41**	21.05**	108.07**	971.81**	1398.81**	19.43**	140.88**
	L.	59	168.23**	284.37**	102.34**	0.87**	3.21**	28.98**	41.61**	0.59**	99.11**
	S.M.× L.	177	100.28**	100.47**	40.17**	0.20**	1.01**	10.05**	11.07**	0.30**	2.17**
	Error	531	49.83	84.15	25.38	0.17	0.80	7.17	10.30	0.14	1.05

***, **: Denote significance at P ≤0.05 and 0.01 probability level, respectively.**

Table 4. Mean squares due to barley Lines (L.) in 10 populations (P.) for different studied traits across four selection methods (S.M.) under kafrdan conditions.

Population	SOV	df	Mean squares								
			Days to 50% heading	Days to 50% maturity	Plant height (cm)	No of spikes/ plant	No of spikelets/ spike	No of grains/ spike	1000 grain weight (g)	Grain yield/ plant (g)	Straw yield /plant (g)
Population 1	R.	2	137.34**	232.14**	68.49**	0.21**	2.91**	26.25**	25.50**	0.13**	1.44**
	S.M.	3	7370.65**	12540.60**	3684.35**	11.35**	158.00**	1421.55**	1370.15**	7.35**	77.15**
	L.	59	334.65**	565.22**	77.88**	0.24**	3.30**	30.09**	28.67**	0.15**	17.70**
	S.M.× L.	177	120.47**	117.94**	50.12**	0.11**	2.01**	2.08**	13.05**	0.11**	1.02**
	Error	531	53.68	90.85	26.78	0.08	1.13	10.27	9.93	0.06	0.57
Population 2	R.	2	153.36**	259.23**	79.92**	0.29**	4.10**	36.96**	24.89**	0.29**	2.70**
	S.M.	3	8149.90**	13704.65**	4259.45**	15.10**	218.51**	1951.95**	1319.85**	15.65**	143.20**
	L.	59	754.37**	1276.05**	93.46**	0.33**	4.72**	43.31**	29.21**	0.64**	84.96**
	S.M.× L.	177	101.18**	242.12**	40.12**	0.20**	3.01**	20.07**	20.05**	0.20**	2.13**
	Error	531	60.26	101.93	31.40	0.10	1.60	14.53	9.78	0.12	1.06
Population 3	R.	2	167.76**	283.50**	84.12**	0.30**	5.49**	49.71**	23.46**	0.53**	3.87**
	S.M.	3	8904.50**	15011.10**	4476.40**	15.05**	293.25**	2642.20**	1240.70**	28.20**	205.65**
	L.	59	522.74**	883.11**	90.15**	0.81**	5.89**	53.22**	25.13**	0.57**	166.50**
	S.M.× L.	177	102.83**	241.49**	50.12**	0.50**	4.01**	30.08**	20.04**	0.40**	3.28**
	Error	531	65.91	111.39	33.01	0.12	2.16	19.51	9.21	0.21	1.52
Population 4	R.	2	149.37**	252.60**	93.15**	0.34**	5.59**	50.20**	22.09**	0.50**	5.22**
	S.M.	3	7938.45**	13342.90**	4911.15**	18.05**	296.89**	2696.64**	1165.99**	26.61**	279.21**
	L.	59	1097.40**	1854.25**	151.68**	0.37**	6.11**	54.93**	24.13**	0.54**	65.48**
	S.M.× L.	177	101.77**	243.12**	50.17**	0.20**	3.01**	40.08**	21.04**	0.40**	3.11**
	Error	531	58.76	99.27	36.59	0.13	2.19	19.72	8.69	0.20	1.96
Population 5	R.	2	148.39**	250.94**	101.64**	0.34**	2.28**	20.67**	28.39**	0.32**	2.81**
	S.M.	3	7842.95**	13292.63**	5402.08**	18.05**	121.45**	1100.10**	1508.52**	16.60**	149.53**
	L.	59	205.18**	346.79**	119.12**	0.40**	2.68**	24.17**	33.36**	0.37**	89.03**
	S.M.× L.	177	140.35**	200.58**	60.19**	0.20**	2.00**	10.04**	20.06**	0.30**	2.15**
	Error	531	58.35	98.67	39.96	0.13	0.90	8.13	11.15	0.12	1.11

Table 4. Cont.

Population	SOV	df	Mean squares								
			Days to 50% heading	Days to 50% maturity	Plant height (cm)	No of spikes/ plant	No of spikelets/ spike	No of grains/ spike	1000 grain weight (g)	Grain yield/ plant (g)	Straw yield /plant (g)
Population 6	R.	2	139.61**	235.72**	92.99**	0.77**	2.57**	23.26**	24.90**	0.59**	7.14**
	S.M.	3	7154.33*	12160.94	4731.48*	13.00**	152.60**	1373.05*	1256.85**	14.36**	105.22**
	L.	59	766.13**	1295.26*	148.15**	1.33**	5.21**	46.70**	54.04**	0.44**	122.73**
	S.M.× L.	177	127.34**	146.23**	86.05**	0.50**	2.31**	20.82**	23.53**	0.29**	5.29**
	Error	531	54.91	92.69	36.56	0.10	1.00	9.15	9.79	0.10	0.84
Population 7	R	2	134.93**	228.07**	85.02**	0.31**	2.97**	26.64**	29.90**	0.33**	3.42**
	S.M.	3	7258.48*	12068.54	4503.06*	16.76**	157.44**	1410.74*	1580.60**	17.41**	182.43**
	L.	59	1082.38*	1828.87*	99.70**	0.37**	3.46**	31.19**	34.95**	0.38**	41.00**
	S.M.× L.	177	101.83**	203.07**	70.17**	0.20**	2.01**	24.05**	26.06**	0.20**	2.07**
	Error	531	53.09	89.73	33.42	0.12	1.17	10.47	11.75	0.13	1.34
Population 8	R	2	170.42**	254.19**	71.04**	0.23**	2.57**	23.19**	24.87**	0.22**	2.21**
	S.M.	3	7938.45*	13471.49	3722.06*	12.10**	136.35**	1226.54*	1320.12**	11.22**	117.74**
	L.	59	1197.25*	2023.45*	123.20**	0.37**	2.97**	27.16**	29.23**	0.25**	26.77**
	S.M.× L.	177	132.02**	203.39**	60.14**	0.13**	2.00**	20.05**	16.05**	0.20**	2.05**
	Error	531	59.19	99.99	27.94	0.09	1.00	9.11	9.77	0.08	0.87
Population 9	R.	2	133.17**	224.93**	64.35**	0.32**	5.00**	45.03**	20.54**	0.28**	2.50**
	S.M.	3	7037.64*	12000.45	3403.10*	16.76**	266.91**	2389.62*	921.63**	14.74**	132.39**
	L.	59	288.20**	486.90**	185.51**	0.91**	14.44**	129.78**	50.53**	0.81**	57.71**
	S.M.× L.	177	120.48**	96.81**	60.31**	0.20**	2.03**	31.22**	17.08**	0.20**	2.09**
	Error	531	52.36	88.45	25.30	0.12	1.96	17.70	6.90	0.11	0.98
Population 10	R.	2	134.15**	226.47**	62.75**	0.33**	2.18**	19.62**	27.71**	0.34**	2.49**
	S.M.	3	7106.47*	12027.40	3326.58*	17.07**	115.16**	1042.51*	1460.83**	18.04**	131.56**
	L.	59	191.61**	323.73**	99.58**	1.23**	3.43**	31.18**	46.91**	0.54**	91.91**
	S.M.× L.	177	100.32**	150.55**	50.17**	0.30**	2.01**	14.05**	24.07**	0.30**	2.16**
	Error	531	52.74	89.05	24.66	0.13	0.85	7.71	10.90	0.13	0.98

***, **: Denote significance at P ≤0.05 and 0.01 probability level, respectively.**

Mean performance of barley lines

The mean performance for different barley populations and lines obtained from four selection methods are presented in Tables (5 and 6). Results showed significant differences among selection methods and among populations for all studied traits under Izraa and kafrdan conditions. These results in agreement with Choo *et al* (1980), Turcotte *et al* (1980), Van Oeveren (1993), Cooper (1999), Medimagh *et al* (2012), EL-Refaey *et al* (2015), Greveniotis *et al* (2018) and Habouh (2019) who reported significant differences among breeding methods of selection for yield and its components.

Table 5. Mean performance of the ten F_5 populations obtained from four selection methods for different studied traits under Izraa conditions.

Population	Selection methods	Days to 50% heading	Days to 50% maturity	Plant height (cm)	No of spikes/ plant	No of spikelets/ spike	No of grains/ spike	1000 grain weight (g)	Grain yield/ plant (g)	Straw yield /plant (g)
Population 1	BM	98.00	127.40	70.25	3.37	12.47	37.42	40.60	3.72	12.14
	MBM	114.66	137.13	75.62	3.62	13.43	43.78	43.70	4.00	13.07
	PM	105.49	149.06	82.19	3.94	14.59	40.28	47.50	4.35	14.20
	SSDM	117.60	152.88	84.30	4.04	14.97	44.91	48.72	4.46	14.57
	Mean	108.94	141.62	78.09	3.74	13.87	41.60	45.13	4.13	13.49
	LSD	1.41	1.83	1.03	0.05	0.18	0.54	0.59	0.05	0.18
Population 2	BM	102.00	132.60	72.94	4.59	13.39	40.18	41.62	4.50	13.19
	MBM	109.79	142.73	78.51	4.94	14.42	47.01	44.80	4.84	14.20
	PM	119.34	155.14	85.34	5.37	15.67	43.25	48.70	5.26	15.43
	SSDM	122.40	159.12	87.52	5.50	16.07	48.21	49.95	5.40	15.83
	Mean	113.38	147.40	81.08	5.10	14.89	44.66	46.27	5.00	14.66
	LSD	1.49	1.94	1.06	0.07	0.20	0.59	0.61	0.07	0.19
Population 3	BM	106.67	138.67	75.83	5.81	15.43	46.29	38.53	5.69	15.36
	MBM	114.82	149.26	81.62	6.25	16.61	54.15	41.48	6.12	16.53
	PM	124.80	162.24	88.72	6.80	18.05	49.82	45.08	6.65	17.97
	SSDM	128.00	166.40	91.00	6.97	18.51	55.54	46.24	6.83	18.43
	Mean	118.57	154.14	84.29	6.46	17.15	51.45	42.83	6.32	17.07
	LSD	1.56	2.02	1.11	0.08	0.23	0.68	0.56	0.08	0.22
Population 4	BM	100.67	130.87	80.04	5.28	17.38	52.15	40.82	5.11	16.69
	MBM	108.36	140.86	86.16	5.68	18.71	61.02	43.94	5.50	17.96
	PM	117.78	153.11	96.05	6.18	20.34	56.14	47.76	5.98	19.52
	SSDM	120.80	157.04	93.65	6.33	20.86	62.58	48.98	6.13	20.02
	Mean	111.90	145.47	88.97	5.87	19.32	57.97	45.37	5.68	18.55
	LSD	1.47	1.91	1.17	0.08	0.25	0.76	0.60	0.07	0.24
Population 5	BM	100.33	130.43	80.39	4.47	12.22	36.66	43.64	4.53	13.28
	MBM	108.00	140.40	86.54	4.81	13.15	42.89	46.97	4.87	14.29
	PM	117.39	152.61	94.06	5.23	14.30	39.46	51.06	5.30	15.53
	SSDM	120.40	156.52	96.47	5.36	14.66	43.99	52.37	5.43	15.93
	Mean	111.53	144.99	89.37	4.96	13.58	40.75	48.51	5.03	14.76
	LSD	1.46	1.90	1.17	0.06	0.18	0.53	0.64	0.07	0.19

Table 5. Cont.

Population	Selection methods	Days to 50% heading	Days to 50% maturity	Plant height (cm)	No of spikes/ plant	No of spikelets/ spike	No of grains/ spike	1000 grain weight (g)	Grain yield/ plant (g)	Straw yield /plant (g)
Population 6	BM	97.00	126.10	75.36	5.58	11.96	35.88	40.84	5.17	13.95
	MBM	104.41	135.73	81.11	6.01	12.87	41.97	43.96	5.56	15.02
	PM	113.49	147.54	88.17	6.53	13.99	38.62	47.78	6.05	16.33
	SSDM	116.40	151.32	90.43	6.70	14.35	43.05	49.01	6.20	16.75
	Mean	107.83	140.17	83.76	6.20	13.29	39.88	45.40	5.75	15.51
	LSD	1.42	1.85	1.11	0.08	0.18	0.53	0.73	0.08	0.20
Population 7	BM	102.98	133.87	85.18	6.63	13.53	46.60	42.40	3.74	16.76
	MBM	110.23	142.11	81.12	6.10	14.29	46.60	44.53	5.28	17.26
	PM	113.33	148.91	93.18	6.63	17.53	42.87	52.40	6.74	20.76
	SSDM	114.80	149.24	90.44	6.80	15.93	47.79	51.65	6.89	19.24
	Mean	110.41	143.53	86.98	6.54	15.32	45.96	47.75	5.66	18.50
	LSD	1.40	1.82	1.10	0.08	0.19	0.58	0.60	0.07	0.23
Population 8	BM	101.00	131.30	71.03	3.93	12.54	37.61	41.09	3.71	12.13
	MBM	118.17	153.62	83.10	4.60	14.67	44.00	48.08	4.34	14.19
	PM	108.72	141.33	76.46	4.23	13.49	40.48	44.23	4.00	13.06
	SSDM	121.20	157.56	85.24	4.72	15.04	45.13	49.31	4.46	14.56
	Mean	112.27	145.95	78.96	4.37	13.94	41.81	45.68	4.13	13.48
	LSD	1.48	1.92	1.04	0.06	0.18	0.60	0.52	0.05	0.18
Population 9	BM	95.00	123.50	64.40	4.24	13.74	41.23	34.37	4.34	12.73
	MBM	102.26	132.94	69.32	4.57	14.79	48.24	37.00	4.67	13.70
	PM	111.15	144.50	75.35	4.96	16.08	44.38	40.21	5.08	14.90
	SSDM	114.00	148.20	77.28	5.09	16.49	49.48	41.25	5.21	15.28
	Mean	105.60	137.28	71.59	4.71	15.28	45.83	38.21	4.83	14.15
	LSD	1.39	1.80	0.94	0.06	0.20	0.74	0.61	0.06	0.19
Population 10	BM	95.47	124.11	68.15	5.56	12.08	36.24	43.42	5.14	13.88
	MBM	102.76	133.59	73.36	5.98	13.00	42.40	48.74	5.54	14.94
	PM	111.70	145.20	79.74	6.50	14.13	39.00	50.80	6.02	16.24
	SSDM	114.56	148.93	81.78	6.67	14.49	43.48	50.10	6.17	16.66
	Mean	106.12	137.96	75.76	6.18	13.43	40.28	48.26	5.72	15.43
	LSD	1.39	1.57	1.00	0.08	0.18	0.53	0.63	0.08	0.20

Pedigree method (PM), modified bulk method (MBM), single seed descent method (SSDM) and bulk method (BM).

Table 6. Mean performance of the ten F_5 lines obtained from four selection methods for different studied traits under Kafrdan conditions.

Population	Selection methods	Days to 50% heading	Days to 50% maturity	Plant height (cm)	No of spikes/ plant	No of spikelets/ spike	No of grains/ spike	1000 grain weight (g)	Grain yield/ plant (g)	Straw yield /plant (g)
Population 1	BM	100.94	131.22	70.84	3.93	14.68	44.03	43.08	3.17	10.23
	MBM	108.65	141.25	76.25	4.23	15.80	51.51	46.37	3.41	11.02
	PM	118.10	153.53	82.88	4.59	17.17	47.39	50.41	3.70	11.97
	SSDM	121.13	157.47	85.01	4.71	17.61	52.83	51.70	3.80	12.28
	Mean	112.20	145.87	78.74	4.36	16.31	48.94	47.89	3.52	11.38
	LSD 0.05	1.45	1.88	1.02	0.06	0.21	0.63	0.62	0.04	0.15
Population 2	BM	105.06	136.58	75.84	4.53	17.20	51.61	42.33	4.65	13.94
	MBM	113.09	147.01	81.63	4.87	18.52	60.39	45.57	5.00	15.00
	PM	122.92	159.80	88.73	5.30	20.13	55.56	49.53	5.44	16.31
	SSDM	126.07	163.89	91.00	5.43	20.65	61.94	50.80	5.58	16.73
	Mean	116.78	151.82	84.30	5.03	19.12	57.37	47.06	5.17	15.50
	LSD 0.05	1.53	1.99	1.11	0.06	0.25	0.75	0.62	0.05	0.20
Population 3	BM	109.87	142.83	77.81	4.63	19.93	59.79	41.06	6.19	16.71
	MBM	118.26	153.74	83.76	4.98	21.45	69.96	44.20	6.66	17.98
	PM	128.54	167.11	91.04	5.41	23.32	64.36	48.05	7.24	19.55
	SSDM	131.84	171.39	93.38	5.55	23.92	71.75	49.28	7.43	20.05
	Mean	122.13	158.77	86.50	5.14	22.15	66.46	45.65	6.88	18.57
	LSD 0.05	1.60	2.09	1.14	0.07	0.29	0.87	0.60	0.09	0.24
Population 4	BM	103.69	134.79	81.89	4.94	20.04	60.12	39.85	6.00	19.40
	MBM	111.61	145.09	88.14	5.32	21.57	70.34	42.89	6.26	20.88
	PM	121.31	157.71	95.81	5.78	23.45	64.71	46.62	7.22	22.70
	SSDM	124.42	161.75	98.26	5.93	24.05	72.14	47.82	7.20	23.28
	Mean	115.26	149.84	91.02	5.49	22.27	66.82	44.29	6.67	21.56
	LSD 0.05	1.51	1.97	1.20	0.07	0.29	0.88	0.58	0.09	0.28
Population 5	BM	103.34	134.35	85.47	4.94	12.85	38.54	45.22	4.75	14.24
	MBM	111.24	144.61	92.00	5.32	13.83	45.09	48.67	5.11	15.33
	PM	120.91	157.19	100.00	5.91	15.03	41.49	52.90	5.55	16.66
	SSDM	124.01	161.22	102.57	5.80	15.42	46.25	54.26	5.70	17.09
	Mean	114.88	149.34	95.01	5.49	14.28	42.84	50.26	5.28	15.83
	LSD 0.05	1.51	1.96	1.25	0.07	0.19	0.56	0.66	0.09	0.21

Table 6. Cont.

Population	Selection methods	Days to 50% heading	Days to 50% maturity	Plant height (cm)	No of spikes/ plant	No of spikelets/ spike	No of grains/ spike	1000 grain weight (g)	Grain yield/ plant (g)	Straw yield/ plant (g)
Population 6	BM	99.91	129.88	81.51	4.32	13.71	41.14	42.10	4.54	12.25
	MBM	107.54	139.81	87.73	4.65	14.76	48.14	45.32	4.88	13.18
	PM	116.89	151.96	95.36	5.05	16.05	44.29	49.26	5.31	14.33
	SSDM	119.89	155.86	97.81	5.18	16.46	49.37	50.52	5.44	14.70
	Mean	111.06	144.38	90.60	4.80	15.24	45.73	46.80	5.04	13.61
	LSD 0.05	1.46	1.90	1.19	0.06	0.20	0.60	0.62	0.07	0.18
Population 7	BM	106.06	149.87	91.51	5.57	17.09	51.26	52.35	5.68	18.38
	MBM	114.25	137.88	84.19	5.12	15.72	51.26	49.91	5.23	16.91
	PM	116.33	149.87	91.51	5.57	17.09	47.15	56.15	5.68	18.38
	SSDM	118.24	153.72	93.86	5.71	17.52	52.57	55.64	5.83	18.85
	Mean	113.72	147.84	90.27	5.49	16.85	50.56	53.51	5.61	18.13
	LSD 0.05	1.44	1.87	1.14	0.07	0.21	0.64	0.68	0.09	0.28
Population 8	BM	104.03	135.24	71.50	4.06	13.61	40.82	42.27	3.91	12.66
	MBM	111.98	145.57	76.96	4.38	14.65	47.76	45.50	4.21	13.62
	PM	121.72	158.23	83.66	4.76	15.92	43.94	49.46	4.58	14.81
	SSDM	124.84	162.29	85.80	4.88	16.33	48.99	50.73	4.70	15.19
	Mean	115.64	150.33	79.48	4.52	15.13	45.38	46.99	4.35	14.07
	LSD 0.05	1.52	1.97	1.28	0.06	0.24	0.55	0.62	0.06	0.23
Population 9	BM	97.85	127.21	68.07	4.77	18.97	56.91	35.50	4.47	13.41
	MBM	105.33	136.92	73.27	5.14	20.42	66.59	38.21	4.81	14.43
	PM	114.48	148.83	79.65	5.58	22.20	61.26	41.54	5.23	15.69
	SSDM	117.42	152.65	81.69	5.73	22.77	68.30	42.60	5.37	16.09
	Mean	108.77	141.40	75.67	5.30	21.09	63.27	39.46	4.97	14.90
	LSD 0.05	1.43	1.61	0.99	0.09	0.28	0.83	0.52	0.07	0.17
Population 10	BM	98.18	127.64	67.20	4.91	12.53	37.59	44.62	4.95	13.36
	MBM	105.68	137.39	72.33	5.29	13.49	43.98	48.03	5.33	14.39
	PM	114.87	149.34	78.62	5.75	14.66	40.46	52.20	5.79	15.64
	SSDM	117.82	153.17	80.63	5.89	15.04	45.11	53.54	5.94	16.04
	Mean	109.14	141.88	74.69	5.46	13.93	41.79	49.60	5.50	14.86
	LSD 0.05	1.76	1.86	1.20	0.06	0.22	0.67	0.80	0.07	0.24

Pedigree method (PM), modified bulk method (MBM), single seed descent method (SSDM) and bulk method (BM).

For the two traits days to (50%) heading and maturity, the BM selection method had the lowest values under both locations. The two populations 9, and 10 included the earliest lines which registered mean values (95.00 and, 95.47 in the 1st location and 97.85 and 98.18 days in the 2nd location for days to heading) and (123.50 and 124.11 in the 1st location and 123.50 and 124.11 days in the 2nd location for days to maturity), respectively (Tables 5 and 6). With respect to plant height, the two methods of selection BM and MBM had the lowest values for different populations under the two locations under study. While, PM and SSDM had the highest values (96.05 and 96.47 cm) in the two populations 4 and 5, respectively under Izraa conditions, as well as populations 5 (102.57 cm) for SSDM under kafrdan conditions.

Regarding to No. of spikes/plant results revealed that the PM and SSDM were superior in most populations under the two locations. The Population 3 registered the highest No. of spikes/plant (6.80 and 6.97 spikes/plant) for PM and SSDM, respectively and population 7 (6.80 spikes/plant) for SSDM under Izraa conditions, in addition to population 3 and 10 (5.93and 5.89 spikes, respectively) for SSDM and population 5 (5.91 spikes/plant) for PM under kafrdan conditions. Average No. of spikelets/spike and No. of grains/spike showed that the PM and SSDM were superior in the ten populations under both locations and recorded the highest means for population 4 (20.34 and 20.86 spikelets/spike and 56.14 and 62.58 grain, respectively) under Izraa conditions, as well as the two populations 3 and 4 which had values ranging from 23.32 to 24.05 spikelets/spike and from 64.71 to 72.14 grains/spike, respectively under kafrdan conditions (Table 5 and 6).

For 1000 grain weight, the superior performance of the F_5 lines selections were obtained by both PM and SSDM in the one or both populations 5 and 7 under Izraa and kafrdan conditions. Regarding to grain yield/plant, averages exhibited significant differences between the four methods of selection, lines developed by both PM and SSDM in the two populations 3 and 7 ranging from 6.65 to 6.89 g. under the 1st location and in the two populations 3 and 4 ranging from 7.20 to 7.43 g. under the 2nd location. Meanwhile, for straw yield/plant, the two populations 3 and 7 had the highest values for both PM and SSDM ranging from 19.24 to 20.76 g under Izraa conditions as well as population 4 recorded 22.70 g for PM and 23.28 for SSDM under kafrdan conditions (Table 5 and 6).

The obtained results indicate that visual selection for yield by PM and/or SSDM seemed to be an effective under both locations than the two other methods and selection promising lines at early generation for testing in barley could be led to improved higher yielding and more tolerant lines under semiarid conditions. Similar findings were reported by Choo *et al* (1980), Tapsell and Thomas (1983), Van Oeveren (1993), Eshghi *et al* (2011), EL-Refaey *et al* (2015), Arshadi *et al* (2018), Habouh (2019) and Sayd *et al* (2019).

Variance, broad sense heritability, genetic advance and genetic gain

Variance is considered one of the most important factors for efficiency of breeding methods. The obtained values of phenotypic and genotypic variances as well as GCV and PCV were very close for most studied traits which strengthens the greater contribution of selection methods or genotypes rather than environment, so that selection can be operated very well based on the phenotypic values for each trait. Results showed that MBM and the SSDM recorded the highest values of phenotypic variance (σ^2p) and genotypic variance (σ^2g) respectively, for all studied traits as well as phenotypic variance in SSDM for No. of grains/spike, 1000 grain weight, grain yield/plant and straw yield/plant under both locations in addition to plant height and No. of spikes/plant under kafrdan conditions (Tables 7 and 8).

The PCV% was higher than the corresponding GCV% for all the traits which might be due to the interaction of the genotypes with the environment to some degree or other denoting environmental factors influencing the expression of these characters. Data presented in Tables 7 and 8 revealed that the two breeding methods BM and MBM had the highest values of PCV% for all traits, while SSDM followed by PM had the highest values of GCV% for all traits under the two locations. These results are in agreement with those obtained by Eshghi *et al* (2011), Akanska *et al* (2012), Vinesh *et al* (2018) and Ghimire and Mahat (2019).

In the current study, intermediate to high heritability estimates were obtained for four selection methods for all the 9 quantitative traits studied under both locations (Tables 7 and 8). Broad-sense heritability estimate was the highest for SSDM for days to 50% heading and maturity, plant height, No. of spikes/plant, No. of spikelets/spike, No. of grains/spike, 1000 grain weight, grain and straw yield/plant under the two locations ranging from 90.73% days to 50% maturity to 98.85% for straw yield/plant under Izraa and kafrdan locations respectively. These results are in accordance with the findings of Akanska *et al* (2012), Vinesh *et al* (2018), Ghimire and Mahat (2019), Neyhart *et al* (2019) and Yadav *et al* (2019).

Table 7. Phenotypic variance (σ^2p), genotypic variance (σ^2g), phenotypic coefficient of variance (PCV), genotypic coefficient of variance (GCV), broad sense heritability (hb^2), genetic advance (GA) and genetic gain (GG) for four selection methods under Izraa conditions.

Methods	Parameters	Days to 50% heading	Days to 50% maturity	Plant height (cm)	No of spikes/ plant	No of spikelets/ spike	No of grains/ spike	1000 grain weight (g)	Grain yield/ plant (g)	Straw yield /plant (g)
BM	X	100.81	131.05	74.66	4.95	13.67	25.64	41.33	4.76	14.21
	$\sigma^2 g$	31.30	54.10	73.11	1.85	8.26	29.73	17.49	1.11	6.17
	$\sigma^2 p$	49.11	81.78	80.84	2.45	9.66	33.36	23.99	1.39	9.11
	GCV%	5.55	5.61	11.45	27.49	21.02	21.26	10.12	22.12	17.47
	PCV%	6.95	6.90	12.04	31.64	22.73	22.53	11.85	24.75	21.24
	h_b^2%	63.74	66.15	90.44	75.49	85.51	89.12	72.90	79.87	67.68
	GA	9.20	12.32	16.75	2.43	5.47	10.60	7.36	1.94	4.21
	GG	9.13	9.40	22.44	49.20	40.03	41.35	17.80	40.73	29.61
MBM	X	106.76	138.78	78.98	5.22	14.48	27.14	43.73	5.04	15.00
	$\sigma^2 g$	45.28	68.29	92.75	2.64	9.98	39.84	26.71	1.56	8.94
	$\sigma^2 p$	64.78	117.69	117.90	3.24	14.58	46.48	30.09	1.86	11.96
	GCV%	5.80	5.48	11.22	28.63	20.08	21.39	10.87	22.77	18.33
	PCV%	6.94	7.19	12.65	31.72	24.27	23.11	11.54	24.87	21.21
	h_b^2%	69.90	58.03	78.67	81.47	68.46	85.71	88.77	83.83	74.72
	GA	11.59	12.97	17.60	3.02	5.39	12.04	10.03	2.35	5.32
	GG	9.99	8.60	20.50	53.23	34.22	40.80	21.10	42.94	32.65
PM	X	116.04	150.85	85.85	5.67	15.74	29.50	47.54	5.48	16.31
	$\sigma^2 g$	38.32	72.45	87.02	2.36	9.99	35.42	23.46	1.34	7.99
	$\sigma^2 p$	54.83	85.00	91.29	2.61	10.81	37.69	24.63	1.54	9.70
	GCV%	5.80	6.13	11.81	29.43	21.83	21.93	11.08	23.00	18.84
	PCV%	6.94	6.64	12.10	30.95	22.71	22.62	11.35	24.65	20.76
	h_b^2%	69.89	85.23	95.32	90.42	92.41	93.97	95.27	87.04	82.41
	GA	10.66	16.19	18.76	3.01	6.26	11.89	9.74	2.23	5.29
	GG	9.99	11.66	23.75	57.64	43.24	43.79	22.27	44.21	35.24
SSDM	X	119.02	154.72	88.05	5.82	16.14	30.26	48.76	5.62	16.72
	$\sigma^2 g$	56.35	93.51	108.80	3.00	12.65	44.60	28.79	1.78	10.93
	$\sigma^2 p$	59.43	102.17	112.79	3.18	13.22	46.19	30.94	1.81	11.06
	GCV%	6.31	6.25	11.85	29.76	22.04	22.07	11.01	23.73	19.77
	PCV%	6.48	6.53	12.06	30.64	22.53	22.46	11.41	23.97	19.88
	h_b^2%	94.82	91.52	96.47	94.34	95.67	96.55	93.06	98.01	98.85
	GA	15.06	19.06	21.10	3.46	7.17	13.52	10.66	2.72	6.77
	GG	12.65	12.32	23.97	59.53	44.40	44.67	21.87	48.40	40.49

Table 8. Phenotypic variance (σ^2p), genotypic variance (σ^2g), phenotypic coefficient of variance (PCV), genotypic coefficient of variance (GCV), broad sense heritability (h_b^2), genetic advance (GA) and genetic gain (GG) for four selection methods under Kafrdan conditions.

Methods	Parameters	Days to 50% heading	Days to 50% maturity	Plant height (cm)	No of spikes/ plant	No of spikelets/ spike	No of grains/ spike	1000 grain weight (g)	Grain yield/ plant (g)	Straw yield /plant (g)
BM	X	103.82	134.96	77.16	4.66	16.06	30.11	43.03	4.83	14.46
	$\sigma^2 g$	32.77	52.16	112.27	0.37	24.54	87.28	24.79	2.20	18.01
	$\sigma^2 p$	53.30	93.29	121.05	0.42	27.69	96.28	31.73	2.48	21.26
	GCV%	5.51	5.35	13.73	13.12	30.85	31.02	11.57	30.74	29.35
	PCV%	7.03	7.16	14.26	13.97	32.77	32.59	13.09	32.63	31.89
	h_b^2%	61.48	55.92	92.75	88.20	88.62	90.65	78.12	88.73	84.69
	GA	9.25	11.13	21.02	1.18	9.61	18.32	9.07	2.88	8.04
	GG	8.91	8.24	27.24	25.39	59.82	60.85	21.07	59.65	55.64
MBM	X	109.94	142.93	81.63	4.93	17.02	31.91	45.47	5.11	15.27
	$\sigma^2 g$	45.93	77.58	147.51	0.46	31.30	119.41	36.89	3.03	24.62
	$\sigma^2 p$	71.96	121.55	171.87	0.64	40.20	131.89	40.54	3.39	29.15
	GCV%	5.67	5.67	13.69	12.65	30.24	31.50	12.29	31.34	29.88
	PCV%	7.10	7.10	14.78	14.92	34.27	33.11	12.88	33.15	32.52
	h_b^2%	63.82	60.33	85.83	71.83	77.86	90.54	91.00	89.38	84.44
	GA	11.15	14.50	23.18	1.18	10.17	21.42	11.94	3.39	9.39
	GG	9.33	9.33	26.12	22.08	54.97	61.75	24.15	61.04	56.57
PM	X	119.50	155.36	88.73	5.36	18.50	34.69	49.42	5.56	16.60
	$\sigma^2 g$	43.26	76.11	131.55	0.45	29.74	103.77	32.14	2.59	21.95
	$\sigma^2 p$	56.47	92.49	138.72	0.48	30.76	108.97	33.39	2.83	23.57
	GCV%	5.98	6.10	14.05	13.64	32.04	31.92	12.47	31.50	30.67
	PCV%	6.83	6.73	14.43	14.01	32.59	32.71	12.71	32.93	31.79
	h_b^2%	76.61	82.29	94.83	94.75	96.68	95.23	96.25	91.53	93.11
	GA	11.86	16.30	23.01	1.35	11.05	20.48	11.46	3.17	9.31
	GG	10.79	11.41	28.19	27.35	64.90	64.17	25.20	62.08	60.97
SSDM	X	122.57	159.34	91.00	5.49	18.97	35.58	50.69	5.70	17.03
	$\sigma^2 g$	59.22	99.62	165.39	0.56	37.13	130.23	39.57	3.33	27.73
	$\sigma^2 p$	64.69	109.79	170.48	0.60	38.07	134.09	41.87	3.42	28.81
	GCV%	6.28	6.26	14.13	13.63	32.11	32.08	12.41	32.05	30.93
	PCV%	6.56	6.58	14.35	14.06	32.52	32.55	12.77	32.45	31.52
	h_b^2%	91.54	90.73	97.02	93.96	97.53	97.12	94.50	97.54	96.27
	GA	15.17	19.58	26.09	1.49	12.40	23.17	12.60	3.71	10.64
	GG	12.37	12.29	28.68	27.21	65.33	65.12	24.85	65.20	62.51

Meanwhile, values of genetic advance and genetic gain were lower in the two methods of selection BM and MBM compared to those of PM and SSDM for all traits under Izraa and kafrdan conditions. Similar results were reported by Turcotte *et al* (1980), Eshghi *et al* (2011), Ghimire and Mahat (2019) and Neyhart *et al* (2019).

CONCLUSION

In conclusion, the directional selection appears to reduce the range of variability for different studied traits in the F_5 populations. Narrow difference between phenotypic and genotypic variances indicate that grain yield/plant was less affected by environmental factors and this is clear in the high values of broad sense heritability for the ten populations with different selection methods. Values of genetic advance and genetic gain were lower in the two methods of selection BM and MBM compared to those of PM and SSDM for all traits under Izraa and kafrdan conditions. The two methods of selection PM and SSDM were more effective in selecting promising and higher segregant lines for yield and its components, especially for the three populations 3, 5 and 7. These superior segregants could be useful germplasm for future barley breeding programs aiming to improving tolerance under rainfed conditions or cultivated in semiarid regions.

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مقارنة كفاءة طرق تربية لانتخاب تراكيب وراثية محسنة عالية المحصول للشعير تحت ظروف البيئات شبه الجافة

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برنامج الحبوب، المركز العربي لدراسات المناطق الجافة والاراضي القاحلة، دمشق، سوريا، وقسم الاصول الوراثية النباتية، مركز بحوث الصحراء، المطرية، القاهرة، مصر

أجريت هذه الدراسة فى الفترة من ٢٠١٧/٢٠١٦ إلى ٢٠١٩/٢٠١٨ بهدف دراسة كفاءة اربع طرق إنتخاب وهى التجميع والتجميع المحورة وسجل النسب وانحدار النسب من حبة واحدة فى تحسين المحصول ومكوناته فى عشرة عشائر من الشعير سداسي الصفوف وتم تسجيل أثر الإنتخاب على العديد من الصفات: تاريخ طرد ٥٠% من السنابل (يوم) ، تاريخ النضج، إرتفاع النبات (سم) ، عدد السنابل/نبات، عدد الحبوب/سنبلة، وزن ١٠٠٠حبة (غ)، محصول الحبوب/نبات (غ)، محصول القش/نبات (غ) وذلك تحت ظروف البيئات شبه الجافة والمطرية

بمحطتى بحوث ازرع – درعا – سوريا و كفردان – البقاع – لبنان التابعتين للمركز العربي لدراسات المناطق الجافة والاراضي القاحلة – اكساد وكان التصميم المستخدم هو القطاعات كاملة العشوائية ويمكن تلخيص النتائج فيما يلى:١ . أشارت نتائج تحليل التباين والتحليل التجميعى الى وجود إختلافات معنوية بين السلالات المنتخبة فى العشرة عشائر واربعة طرق للإنتخاب، وكذلك التفاعل بين طرق الإنتخاب والعشائر سجل اختلافات معنوية عالية لكل الصفات تحت الدراسة. ٢- أوضحت النتائج أن طريقتى تربية إنتخاب سجل النسب وطريقة انحدار النسب من حبة واحدة لمحصول الشعير، انهما أفضل الطرق المستخدمة في الدراسة، حيث سجلتا أعلى قيم لمتوسطات كل الصفات المدروسة فى العشرة عائلات. وتفوقت السلالات المنتخبة من ثلاثة عائلات ٣ و٥ و٧ حيث اعطت أفضل المتوسطات للسلالات المنتخبة لكل الصفات المدروسة تحت ظروف منطقتي ازرع وكفردان. ٣- سجلت طريقتي انتخاب التجميع المحورة وانحدار النسب من حبة واحدة اعلى قيم للتباين المظهري (σ^2p) والتباين الوراثي (σ^2g) على الترتيب لجميع الصفات المدروسة، بالاضافة الى التباين المظهري لصفة عدد الحبوب/سنبلة ووزن ١٠٠٠حبة و محصول الحبوب/نبات ومحصول القش/نبات عند الانتخاب بطريقة انحدار النسب من حبة واحدة تحت كلا الموقعين، وكذلك لصفتى ارتفاع النبات وعدد الحبوب/سنبلة تحت ظروف منطقة كفردان. ٤- تراوحت تقديرات قيم كفاءة التوريث بالمعنى الواسع من المتوسطة إلى العالية تبعا لطريقة الانتخاب والعائلة في جميع الصفات المدروسة. بينما اشارت قيم التقدم الوراثي والمكسب الوراثي الى تفوق طريقتي انتخاب سجل النسب وانحدار النسب من حبة واحدة لجميع الصفات تحت ظروف منطقتي ازرع وكفردان. ٥- اظهرت النتائج أن الانتخاب المبكر لصفات محصول الحبوب ومكوناته بطريقة سجل النسب و/أو انحدار النسب من حبة واحدة يبدو أنه فعال ويمكن من خلاله الحصول على سلالات محسنة عالية المحصول ومتحمله للاجهادات البيئية وخاصة للسلالات المنتخبة من الثلاثة عائلات ٣ و٥ و٧ تحت ظروف البيئات شبه القاحلة.

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