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Research paper

Estimation of Genetic Variability, Heritability, Genetic Advance and Correlation for Yield and Some Quantitative Traits in Irrigated Faba bean (*Vicia faba* L.) Genotypes in Northern Sudan

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ABSTRACT

Faba bean, a grain legume, is an important crop which provides rich protein nutrition for human and animal. The study was carried out at Merowe Research Station Farm, Sudan during the two winter seasons of 2016/17 and 2017/18. The objectives of this study were to estimate the genetic variability, heritability, genetic advance and correlation among some quantitative traits with seed yield in 14 Faba bean genotypes. Growth parameters investigated included days to 50% flowering, days to 90% maturity, plant height (cm), number of pods per plant, number of seeds per plant, number of seeds per pod, 100 – seed weight (g), seed yield per plant (g) and seed yield (kg ha^{-1}). Analysis of variance showed significant variation among the genotypes for all tested characters. The results indicated that the entries no. 2, 6, 4, 1 and 10 out – yielded the second check SM – L in seed yield, with average yield advantages amounting to 16.8, 14.6, 11.6, 5.9 and 4.2%, respectively. 100 – seed weight showed the highest genotypic and phenotypic variances (186.76 and 1063.09) whereas number of pods per plant showed the lowest ones (0.24 and 2.65). Also, the highest heritability was recorded on 100 – seed weight, days to 50% flowering, days to 90% maturity and number of seeds per pod, while the lowest was for number of pods per plant (9.05%). Genetic advance was higher for 100 – seed weight (11.80) and seed yield per plant (6.37). Therefore, this research suggests that 100-seed weight and number of seeds per pod can be good selection criteria for improving seed yield in Faba bean. Positive and highly significant correlation was observed for seed yield with seed yield per plant, number of pods per plant and number of seeds per pod. These characters could be used as selection criteria in Faba bean breeding program.

Keywords: Faba bean, characters, genetic variability, heritability, correlation, seed yield.

التباين الوراثي والتوريث والتقدم الوراثي ومعامل الارتباط للإنتاجية وبعض الصفات الكمية لطرز من الفول المصري تحت الظروف المروية في شمال السودان

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الفول المصري من الحبوب البقولية، وهو محصول مهم وغني بالبروتين للإنسان والحيوان. أجريت الدراسة في مزرعة محطة بحوث مروي بالسودان خلال موسمي الشتاء 17/2016 و18/2017. هدفت هذه الدراسة إلى تقدير التباين الوراثي، والتوريث، والتقدم الوراثي، والارتباط بين بعض الصفات الكمية مع الغلة الحبية. البيانات المأخوذة تضمنت عدد الايام حتى 50 % من الازهار، عدد أيام النضج الفسيولوجي 90٪، طول النبات (سم)، عدد القرون في النبات، عدد البذور في النبات، عدد البذور في القرن، وزن المائة حبة (جم)، انتاجيه النبات (جم) والغلة الحبية (كجم / هكتار). أظهر تحليل التباين وجود فروق معنوية بين الطرز الوراثية لجميع الصفات المدروسة. أشارت النتائج ان السلالات رقم 2 و 6 و 4 و 1 و 10 اعطت اعلى انتاجيه وتفوقت على الشاهد الثاني SM - L بنسبه بلغت 16.8، 14.6، 11.6، 5.9 و 4.2٪ على التوالي. أظهر وزن المائة حبه أعلى تباين وراثي ومظهري (186.76 و 1063.09) بينما أظهر عدد القرون في النبات أقلها (0.24 و 2.65). كما سجل وزن المائة حبة وعدد الايام حتى 50 % من الازهار وعدد أيام النضج الفسيولوجي 90% وعدد البذور في القرن أعلى نسبة توريث بينما سجلت أقل نسبة توريث لعدد القرون في النبات (9.05٪). كان التقدم الوراثي أعلى بالنسبة لوزن المائة حبة (11.80) وإنتاجيه النبات بالجرام (6.37) لذلك تشير هذه الدراسة إلى أن وزن المائة حبة وإنتاجية النبات يمكن أن تكون معايير انتخاب جيدة لتحسين محصول البذور في الفول المصري. ولوحظ ارتباط موجب وعالي المعنوية بين انتاجيه النبات وعدد القرون في النبات وعدد البذور في القرن ويمكن استخدام هذه الصفات كمعايير اختيار في برنامج تربية الفول المصري.

الكلمات المفتاحية: الفول المصري، الصفات، التباين الوراثي، التوريث، الارتباط، الغلة الحبية

Introduction

Faba bean (*Vicia faba* L.) is one of the most important legumes for its seed high protein content and nutritional value (Crepona *et al.*, 2010). The crop is widely cultivated and used as human food and animals feed. World production has been variable during the past 10 years ranging from a low of 3.58 million tons in 1997/98 to a 4.85 million tons in 2002/03, trending upward (FAO, 2004).

In the Sudan, Faba bean is grown in the Northern and Nile States, where temperature is relatively cooler and winter longer; winters are shorter and worm southwards (Salih and Mohamed, 1992). Moderate moisture supply is essential, with highest requirement at about 9 -12 weeks after establishment (Duke, 1981).

In Sudan, Faba bean is grown as a winter crop under irrigation mainly in the Northern State in about 70% of the total cultivated area and the River Nile State in about 30% of the total cultivated area. It is also grown to a limited extent in Khartoum State and Jabel Marra in Western Sudan due to the suitability of the environmental conditions (Salih and Salih, 1996). Lately, it was introduced to the larger irrigated schemes of Gezeira, Rahad and New Halfa.

The genetic improvement of crop desired traits depends on the nature and magnitude of genetic variability and interactions involved in the inheritance of these traits which can be estimated using statistical techniques. Many researchers studied heritability for seed yield, yield components and the other agro-morphological traits in Faba bean. Seed yield is a complex trait that is quantitatively inherited with low heritability value (Bond, 1966).

Abo El-Zahab *et al*. (1980) studied broad-sense heritability for number of pods per plant, number of seeds per pod, seed weight and seed yield per plant. Their findings indicated that heritability values were 88.4, 99.9, 84.3 and 21.3% respectively. Bora *et al.* (1998) stated that the high heritability was followed by high genetic advance for fruiting branches/plant, pods/plant and seed yield/plant indicating the scope for their improvement through selection. The low heritability and consequent limited genetic advance for yield in response to selection had led many scientists to search for characters which are associated with yield but which are more highly heritable (De Pace, 1979).

Ibrahim (2010) indicated narrow-sense heritability was high for 100-seed weight and low for seed yield per plant. Kalia and Sood (2004) revealed high broad-sense heritability estimates (0.97) along with high genetic advance (126 %) for pod yield.

Another important mathematical application in agriculture is the correlation analysis, which describes the mutual relationship between different pairs of characters without providing the nature of cause and effect relationship of each character. Significant positive correlations were detected between Faba bean seed yield and each of number of pods/plant, number of seeds/plant, seed weight/plant and biological yield (Alghamd, 2007). Tadesse *et al.* (2011) indicated number of pods/plants, number of seeds/pod, thousand seed weight and plant height for Faba bean had significant association with seed yield/plot. The seed yield/plant exhibited positive and significant correlation with clusters/plant, pod length, plant height, branches/plant, pods/plant and hundred seed weight (Badolay *et al.*, 2009).

The present study was carried out to estimate the variability, heritability, genetic advance and correlation for yield and some yield components of fourteen Faba bean genotypes on the study area.

Materials and Methods

Genetic materials

Fourteen Faba bean genotypes (Table 1) comprising of twelve single plant selection, which were selected from different parts of Faba bean production at Merowe locality and two standard checks (Shendi and SM–L) were investigated. The two check varieties were released by the Agricultural Research Corporation (ARC) for commercial cultivation in the Sudan.

Experimental site and cultural practices

The experiments were conducted at Merawi Research Station Farm, Northern state (Latitude: 18° 27' 0" N, Longitude: 31° 49' 59" E, Elevation: 258 meters). Genotypes were arranged in Randomized Complete Block design with three replications. Planting was on ridges 60 cm apart with intra-row spacing of 20 cm, and 2 seeds per hole. The plot size was 5 ridges each 5m long. Sowing date was in the second week of November during the two seasons. Irrigation was carried out at 12- 14 days intervals to avoid any water stress. Nitrogen was added as urea (46%) at a rate of 43 kg N/ha in the 3rd week after sowing and weeds populations were kept to a minimum by hand removal during the first month after sowing. In both seasons, plants were sprayed with 2, dimethoxyphosphorylsulfanyl-N-methylacetamide against the aphid (*Aphis fabae* sp.), when it appeared in the field. Seed yield was assessed from a net area of 5 m^2.

Data collection

The following parameters were measured for two consecutive seasons: number of days to 50% flowering, number of days to 90% maturity, plant height (cm), five plants were randomly selected from each replicate and their height were measured from the tip to the ground level. Number of pods per plant, number of seeds per plan and number of seeds per pod also were recorded, 100 - seeds weight was recorded from the weight of 100 - seeds of bulk seeds of plant sampled. Seed yield per plant (g) and seed yield per hectare was obtained by threshing and weighting the seed of each replicated plot and the mean of three plots was recorded.

Statistical analysis

The data were subjected to analysis of variance across two seasons using MSTATC software computer package. Then means were compared using Duncan's Multiple Range Test (DMRT). Correlation coefficients were estimated as the formula suggested by Johnson *et al*. (1955).

Estimation of genetic parameters

The mean squares were used to estimate genotypic and phenotypic variances according to Sharma (1998). Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were estimated according to the method suggested by Burton and De Vane (1953). Broad sense heritability was calculated as the ratio the genotypic variance to the phenotypic variance according to Falconer and Mackay (1996). Expected genetic advance as part of the mean (GA) for each character at 5% selection intensity (K=2.056) was computed using the method illustrated by Allard (1960). Expected genetic advance as percent of mean (GAM) was calculated to compare the extent of predicted advance of different traits under selection, using the formula described by Comstock and Robinson (1952).

Results and Discussion

Variability across environments

Significance of mean squares due to different sources of variability for studied traits in combined is summarized in Table (2). Results revealed that the studied genotypes differed significantly for all the traits in combined analyses. This indicates the presence of sufficient variability among the evaluated genotypes for the characters under consideration. This result was in conformity with the results reported by many authors; Hanna (1995), Salem (2007) and Tafere *et al*. (2013). Also the results showed that the mean square of environments (seasons) x genotypes interaction were significant for all characters measured except for the plant height and number of seeds per pod.

The mean performances for different traits of fourteen Faba bean genotypes are given in Tables (3 and 4). Data revealed that the entry no. 12 possessed the earliest flowering (34 days) and maturity date (92), while entries no. 5 and 8 revealed days to flowering and maturity of plants last for 44 – 100 and 44 – 101days, respectively. Regarding plant height, entry no.7 possessed the tallest plants (98 cm) whereas, entry no. 12 exhibited the shortest plants (78 cm) (Table 3). For number of pods per plant, entry no 6 showed the highest pods per plant (14.7) whereas the entry no. 8 gave the lowest pods per plant (8.9). Results also showed that entry no.1 possessed the highest values for number of seeds per plant and number of seeds per pod (38.7 and 2.6, respectively). However, entries no 11, 3 and 12 possessed the lowest values for the number of seeds per plant and number of seeds per pod (Table 4). For 100 - seed weight, entry no. 12 possessed the heaviest seed weight (97g) among the fourteen genotypes, while, entry no. 8 recorded the lowest value (47 g). Entries no. 1, 10 and 4 exhibited the highest values of 104, 98 and 98g for seed yield per plant, respectively. On the other hand, entries no. 8, 7 and 3 exhibited the lowest values for seed yield per plant. The highest mean seed yield was obtained by the variety Shendi, followed by the entries 2, 6, 4, and 1. While the lowest seed yield was obtained by the entries no. 8 and 5. Entries no. 2, 6, 4, 1 and 10 out - yield the second check SM – L by 16.8, 14.6, 11.6, 5.9 and 4.2%, respectively. Seven of the tested genotypes had yield exceeding the overall mean of the trial. From the above - mentioned results, it could be concluded that entry no. 6 showed the highest number of pods per plant and number of seeds per plant. These results reflect that the selection prospects within this genotype to improve the performance through breeding program.

Genetic parameters

Estimates of phenotypic variance, genotypic variance, genotypic coefficient of variation, phenotypic coefficient of variation, broad sense heritability, genetic advance and genetic advance as a percentage of the mean from the partition of mean squares in combined analysis is presented in Table (5). The maximum phenotypic variance was recorded by 100 – seed weight (186.76) followed by seed yield per plant (65.86). Similarly, the genotypic variances for these characters were also high indicating that the genotype could be reflected by the phenotype and the effectiveness of selection based on the phenotypic performance for these characters. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) ranged from 0.35 to 2.07% (number of seeds per pod), 1334 to 7593.50% (100 – seed weight), respectively. Generally, the PCV values were higher than GCV values for all the traits studied that reflect the influence of environment on the expression of all the traits. Similar results were also obtained by

Ahmad (2016). Heritability (H^2) in broad sense estimates were generally moderate for most studied traits which ranged from 9.05% for number of pods per plant to 17.57% for 100 – seed weight. The highest estimates of broad sense heritability (H^2) was recorded as 17.57, 17.56, 17.39 and 17.24% for 100 – seed weight, days to 50% flowering, days to 90% maturity and number of seeds per pod, respectively (Table 5). High estimates of heritability indicated that selection based on mean would be successful in improving these traits. Moreover, the value is low for the rest of the traits including seed yield per plant, indicating limited possibility of improvement of this characters through selection. Similar results were obtained by Toker (2004) who recorded high to moderate heritability for traits containing days to 50% flowering and low heritability for number of pods per plant. Dabholkar (1992) explained that whenever values are stated for heritability of a character, it refers to a particular population under particular environmental conditions. He classified heritability estimates as low (5 to 10%), medium (10 to 30%) and high (>30%). Genetic seeds that expected from selecting the top 5% of the genotypes, as a percentage of the mean, varied ranged from 13.1% for 100 – seed weight to 1.6% for days to 90% maturity, indicating an increase of 1.6 to 13.1% made by selection on these traits under the similar conditions (Table 5).

Correlation coefficient analysis

In this connection, correlation studies are of interest because they indicate the relative ease with which the different characters can be selected together. In faba been and other food legumes, according to (Cakmakci *et al*., 2003). The simple correlation coefficients determined at the end of the research between the characteristics investigated are presented in Table (6) for mean values over the two seasons. Highly significant positive correlation values were detected between seed yield and seed yield per plant (r = 0.6984**), number of pods per plant (r =0.6126*) and number of seeds per pod (r = 0.5221*). The strong association of these characters can be used during selection to improve the yield potential of the crop.

There was significant positive correlation between seed yield and number of pods per plant confirmed the results, obtained by Nigem *et al.* (1990), Berhe *et al.* (1998) and Ulukran *et al.* (2003) in faba been. On the other hand, there was non significant and negative correlation between seed yield and 100 - seed weight obtained in this study (-0.0378n.s) disagreed with the results obtained by Picard and Parthelon (1981) and Nigem *et al*. (1990). Also there was non significant correlation between the seed yield and days to flowering, days to maturity, plant height and number of seeds per plant. There was negative correlation between seed yield per plant and its days to 50% flowering, days to 90% maturity and plant height (Table 6).

There were positive and significant correlations between days to 50% flowering and days to 90% maturity (r = 0.8974***) and plant height (r = 0.7111**). 100 – seed weight was negatively and significantly correlated with the days to flowering, days to maturity, plant height and number of seeds per pod.

The character number of pods per plant correlated highly significantly and positively with seed yield pea plant (r = 0.7880***). On the other hand, it showed no significant and negative correlation with plant height. Also there were negative and no significant correlations between number of pods per plant and 100 - seed weight (r = -0.2256n.s), and this result is not in agreement with the results of Tosun *et al.* (1991).

Plant height exhibited negative and no significant correlation with number of pods per plant, seed yield per plant and seed yield, but it was correlated positive and significant with days to 50% flowering and days to 90% maturity (Table 6).

Conclusion

The mean squares due to genotypes and seasons were highly significant for most traits studied. Similarly, except the plant height and number of seeds per pod, the mean squares due to season x genotype interaction were significant for all traits. Genotypic coefficient of variation (GCV) values were lower than phenotypic coefficient of variation (PCV) values for all the traits which reflect the influence of environment on the expression of traits. High genotypic coefficient of variation observed for 100 - seed weight followed by seed yield per plant. High heritability estimates were recorded for 100 – seed weight (17.57%) and days to 50% flowering (17.56%). The result of genetic advance as percent of mean an increase of 1.6% to 13.1% magnitude made by selection. The traits which revealed high magnitude of heritability and genetic advance (100 – seed weight, number of seeds per plant and number of seeds per pod). So, it is concluded that these three traits may be considered as the selection criteria for the improvement of seed Faba bean.

Seed yield (kg ha^{-1}) was positively and significantly ($p \leq 0.05$) correlated with seed yield per plant, number of pods per plant and number of seeds per pod. The characters positively and significantly associated with seed yield could be reliable selection criteria for seed yield in Faba bean under irrigated conditions.

Table (1): Pedigree of the 14 Faba bean genotypes used in the study

Genotype no.	Cultivar / line	Pedigree
1	Glass 2014/2015-S.P.S, no. 37	Single plant selection from introduced unknown source grown at Merowe farmer fields
2	Glass 2014/2015-S.P.S, no. 39	Single plant selection from introduced unknown source grown at Merowe farmer fields
3	Glass 2014/2015-S.P.S, no. 40	Single plant selection from introduced unknown source grown at Merowe farmer fields
4	Glass 2014/2015-S.P.S, no. 41	Single plant selection from introduced unknown source grown at Merowe farmer fields
5	Glass 2014/2015-S.P.S, no. 42	Single plant selection from introduced unknown source grown at Merowe farmer fields
6	Glass 2014/2015-S.P.S, no. 43	Single plant selection from introduced unknown source grown at Merowe farmer fields
7	Glass 2014/2015-S.P.S, no. 44	Single plant selection from introduced unknown source grown at Merowe farmer fields
8	Glass 2014/2015-S.P.S, no. 45	Single plant selection from introduced unknown source grown at Merowe farmer fields
9	Glass 2014/2015-S.P.S, no. 47	Single plant selection from introduced unknown source grown at Merowe farmer fields
10	Glass 2014/2015-S.P.S, no. 48	Single plant selection from introduced unknown source grown at Merowe farmer fields
11	Ossly 2013/2014)-S.P.S, no.5	Single plant selection from introduced unknown source grown at Merowe farmer fields
12	Ossly 2013/2014)-S.P.S, no.6	Single plant selection from introduced unknown source grown at Merowe farmer fields
13	Shendi (check)	Released commercial variety
14	SM – L (check)	Released commercial variety

Table (2): Mean squares of seed yield and some yield components for 14 Faba bean genotypes grown during two winter seasons 2016/17 and 2017/18 at Merawi

Characters	Season (d.f = 1)	Genotype (d.f = 13)	Seas. X geno. (d.f = 13)	Pooled error (d.f = 52)
Days to flowering	933.333***	63.249***	16.000***	1.306
Days to maturity	1196.298***	40.558***	19.964***	1.755
Plant height (cm)	4453.030***	153.012**	81.145n.s	55.445
No. of pods /plant	172.889*	23.651**	22.153**	7.798
No. of seeds /plant	2416.075*	273.955***	198.908**	70.068
No. of seeds /pod	0.947*	0.394***	0.093n.s	0.087
100-grain weight	4680.107***	1243.089***	122.517***	28.748
Seed yield (g)	6413.762*	1347.249**	952.044*	540.482
seed yield (kg ha^{-1})	49272185.190***	949858.128***	300038.293*	124239.708

*, ** and *** Significant at 0.05, 0.01 and 0.001 levels of probability, respectively.
n.s = non - significant difference at 0.05 probability level.

Table (3): Average performance for some vegetative traits of 14 Faba bean genotypes in the studies, combined over two seasons

Entry no.	DF	DM	PH
1	42 ^{bc}	101 ^{a}	87 ^{abc}
2	41 ^{bc}	99 ^{abc}	87 ^{abc}
3	44 ^{a}	99 ^{abcd}	89 ^{abc}
4	38 ^{d}	96 ^{e}	88 ^{abc}
5	44 ^{a}	100 ^{ab}	91 ^{ab}
6	43 ^{ab}	98 ^{abcde}	90 ^{abc}
7	41 ^{bc}	99 ^{abc}	98 ^{a}
8	44 ^{a}	101 ^{a}	91 ^{ab}
9	43 ^{ab}	98 ^{abcde}	90 ^{abc}
10	38 ^{d}	97 ^{cde}	81 ^{bc}
11	34 ^{e}	93 ^{f}	84 ^{bc}
12	34 ^{e}	92 ^{f}	78 ^{bc}
13	40 42 ^{cd}	97de	88 ^{abc}
14	43 ^{ab}	98 ^{bcde}	93 ^{ab}
Mean	41	98	88
S.E ±	0.466	0.540	3.039
C.V (%)	2.7	1.3	8.3

DF: Days to 50 % flowering, DM: Days to 90 % maturity and PH: Plant height (cm).
According to Duncan's Multiple Range Test (DMRT). Data in the same column with the same letter/s are not significantly different.

Table (4): Seed yield (kg ha^{-1}) and its primary components of 14 Faba bean genotypes in the study, combined over two seasons.

Entry no.	SY	NPP	NSP	NSPO	HSW	SY (g)
1	2335 ^{a}	13.5 ^{ab}	38.7 ^{a}	2.6 ^{a}	56 ^{cde}	104 ^{a}
2	2640 ^{a}	11.8 ^{ab}	29.7 ^{abc}	2.5 ^{abcd}	59 ^{cd}	82 ^{ab}
3	1648 ^{bcd}	10.4 ^{ab}	19.6 ^{bc}	1.9 ^{de}	69 ^{b}	70 ^{ab}
4	2452 ^{a}	13.9	30.9 ^{abc}	2.2 ^{abcde}	69 ^{b}	98 ^{a}
5	1581 ^{cd}	13.0 ^{ab}	26.8 ^{abc}	2.0 ^{bcde}	65 ^{bc}	81 ^{ab}
6	2574 ^{a}	14.7 ^{a}	35.7 ^{ab}	2.5 ^{abcd}	54 ^{de}	88 ^{ab}
7	2061 ^{abc}	9.4 ^{ab}	22.8 ^{abc}	2.4 ^{abcde}	54 ^{de}	64 ^{ab}
8	1380 ^{d}	8.9 ^{b}	21.7 ^{bc}	2.3 ^{abcde}	47 ^{e}	50 ^{b}
9	2078 ^{abc}	13.0 ^{ab}	34.1 ^{abc}	2.6 ^{ab}	49 ^{de}	87 ^{ab}
10	2294 ^{ab}	14.3 ^{ab}	34.0 ^{abc}	2.3 ^{abcde}	64 ^{bc}	98 ^{a}
11	2052 ^{abc}	9.5 ^{ab}	18.2 ^{c}	1.8 ^{e}	89 ^{a}	79 ^{ab}
12	2136 ^{abc}	10.6 ^{ab}	21.1 ^{bc}	2.0 ^{cde}	97 ^{a}	94 ^{a}
13	2695 ^{a}	13.8 ^{ab}	34.9 ^{ab}	2.5 ^{abc}	54 ^{de}	95 ^{a}
14	2196 ^{abc}	12.7 ^{ab}	31.6 ^{abc}	2.3 ^{abcde}	69 ^{b}	92 ^{a}
Mean	2152	12.1	28.6	2.3	64	84
S.E ±	143.897	1.140	3.417	0.120	2.188	8.664
C.V (%)	16.3	23.0	29.2	12.7	8.3	25.0

SY: Seed yield (kg ha^{-1}), NPP: Number of pods per plant, NSP: Number of seeds per plant, NSPO: Number of seeds per pod, HSW: Hundred seed weight (g) and SY (g): Seed yield per gram.

According to Duncan's Multiple Range Test (DMRT) the data in the same column with the same letter are not significantly different.

Table (5): Some of statistical results for different agronomic characters of 14 Faba bean genotypes grown during two winter seasons; 2016/17 and 2017/18.

Characters	δδ²ph	δδ²g	GGCV ((%)	PPCV ((%)	HH² ((%)	GGA	GGAM (%)
Days to flowering	44.58	7.83	19.98	47.69	17.56	2.41	5.9
Days to maturity	19.72	3.43	13.22	31.71	17.39	1.59	1.6
Plant height (cm)	77.07	11.97	24.71	550.50	15.53	2.81	3.2
No. of pods /plant	2.65	0.24	1.71	18.92	9.05	0.30	2.5
No. of seeds /plant	82.50	12.50	89.28	589.28	15.15	2.82	9.9
No. of seeds /pod	0.29	0.05	0.35	2.07	17.24	0.19	8.3
100-seed weight	1063.0	186.7	1334.00	7593.50	17.57	11.80	13.1
Seed yield/ plant (g)	448.28	65.86	470.42	3202.00	14.69	6.37	7.6

Phenotypic variance= δ^2ph, genotypic variance= δ^2g, genotypic coefficient of variation= GCV, phenotypic coefficient of variation= PCV, broad sense heritability= H², genetic advance= GA and genetic advance as a percentage of the mean (GAM)

Table (6): Estimates of correlation coefficient for seed yield, yield components and some vegetative characters of 14 Faba bean genotypes grown during two winter seasons 2016/17 and 2017/18 at Merawi.

Characters	DF	DM	PH	NPP	NSP	NSPO	100-SW	SYP
DM	0.8974***							
PH	0.7111**	0.6459*						
NPP	0.1418n.s	0.0913n.s	-0.1310n.s					
NSP	0.2168n.s	0.0569n.s	0.2773n.s	0.1586n.s				
NSPO	0.4047n.s	0.4872n.s	0.3104n.s	0.4708n.s	0.0885n.s			
100-SW	-0.7616**	-0.8214***	-0.6316*	-0.2256n.s	0.0570n.s	-0.7728**		
SYP	-0.3447n.s	-0.3323n.s	-0.4883n.s	0.7880***	0.2013n.s	0.2393n.s	0.2421n.s	
S.Y (kg/ha)	-0.3153n.s	-0.2712n.s	-0.2200n.s	0.6126*	0.0850n.s	0.5221*	-0.0378n.s	0.6984**

DF: Days to 50 % flowering, DM: Days to 90 % maturity, PH: Plant height (cm), NPP: Number of pods per plant, NSP: Number of seeds per plant, NSPO: Number of seeds per pod, HSW: Hundred seed weight (g), SYP: Seed yield per plant (g) and SY: Seed yield (kg ha^{-1})

*, ** and *** Significant at 0.05, 0.01 and 0.001 levels of probability, respectively.

n.s = non - significant difference at 0.05 probability level.

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