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Genotypic and phenotypic correlation in three segregated populations of Peas (*Pisum sativum L.*)

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Abstract

The experiment was conducted during two successful winter seasons of 2021/ 2022 and 2022/2023 at the Research Farm of the Faculty of Agriculture, Sohag University. Three F_3 and F_4 segregated Peas populations were used; population one derived from (Cash x Sweet1), population two derived from (Sweet1 x Sweet2) and Population three derived from (Progress x Sweet2); to estimate the genotypic and phenotypic correlation values between ten studied traits. The estimated values of genotypic correlation between most of the studied traits were higher in values than their phenotypic correlation values, this implies, a strong relationship in different pair of characters. The genotypic and phenotypic correlation values among plant dry seed yield and other traits like height of plant, plant branches number, plant pods number, length of pod, pods weight and pod filing percentage was highly significant and positive. Thus, these traits found as most vital component characters and associated positively with plant dry seed yield**.**

Keywords: Phenotypic, Genotypic, Correlation, Peas

INTRODUCTION

Peas (*Pisum sativum* L.) is commonly called as garden peas, sugar peas and snap peas. It belongs to the family *Fabaceae* (*Leguminosae*) with the chromosome number 2n=14. It is native of Central Asia, the Near East, Abyssinia, and the Mediterranean is considered as center of origin based on genetic diversity (Asha *et., al.,* 2020). It is a cool season crop and it is mainly grown as winter vegetable crop in Egypt. It is grown almost all over the world for its edible seeds. They can be purchased fresh, canned, or frozen, and dried peas are commonly used in soups. Some varieties, including sugar snap peas and snow peas, produce edible pods and are eaten raw or cooked like green beans. It is popular in East Asian cuisines. The plants are very easy to grow, and the seeds are a good source of protein and dietary fiber. Peas is one of the most famous types of vegetables that contain a high percentage of vitamins and nutrients that enhance the health of the body and protect it from diseases and viruses, as it contains vitamin C, fiber, antioxidants, and other elements and vitamins that are important for the health of the body (Harmankaya *et al.,* (2010) and Lam *et al*., (2018)). Peas is the third most important grain legume seeds crop globally after beans and chickpea. Peas crop is grown for two purposes; its green pods and dried seeds and its superior quality protein like lysine content, the limiting amino acid in cereals. Peas has great nutrient value and contain vitamins A, B and C, along with minerals (including calcium, potassium and iron), dietary fiber and antioxidant compounds. It helps in reducing inflammation and lowers the risk of chronic conditions, including heart disease and diabetes (Urbano *et al*., 2003). It is considered the second most important protein crop after soybean (FAOSTAT, 2022). In Egypt, the cultivated area with peas was estimated at 16320 ha in 2022 and it produced a total of 10179.4 kg (FAOSTAT, 2022). The cultivated pea area in Egypt is very low and not sufficient for consumption or nutritional needs. High yield is the main goal of all crop breeding programs is developing genotypes with the potential to exceed commercial varieties (Sharma *et al.,* 2020). Selection or backcross breeding methods are widely used to improve self-pollinating crops and to produce new lines. These breeding methods such as pedigree selection are highly successful in developing quantitative traits in peas (El-Dakkak (2016 a and b) and Rashwan and El-Shaieny (2016)). The correlation coefficient evaluates the reciprocal relationship among different plant quantitative characteristics and identifies the specific traits and characteristics suitable for selection aimed at enhancing genetic yield. The correlation coefficient can be calculated at both the genetic and observable characteristic levels (Gupta *et al*., (2020)). Seed yield is a quantitative trait affected by several traits. Thus, the correlation among seed yield and its contributing traits improves breeding efficiency via the use of suitable selection indices (Tadesse and Leta (2019)). Recent researchs (Georgieva *et al.,* (2015), Singh *et al.,* (2016), Asha *et al.,* (2020), Rahman *et al.,* (2021) and Chauhan *et al.,* (2023)) focuses on the correlation between seed yield and its components and other morphological traits through selection and varieties evaluation. The aim of this study is to determine the simple correlation coefficient between studied traits and seed yield in two segregation generations in three peas populations on two levels genotypic and phenotypic, this helps in the selection of high yielding lines in peas breeding programs.

MATERIALS AND METHODS

The present study was carried out in the field during the winter seasons of 2021/ 2022 and 2022/2023 at the Research farm of the Faculty of Agriculture, Sohag University. Three F_3 and F_4 segregated Peas populations were used; Pop.1 derived from (Cash x Sweet1), Pop.2 derived from (Sweet1 x Sweet2) and Pop.3 derived from (Progress x Sweet2), produced by Prof. Dr. Abo-Bakr A. A. El-Dakkak (Horticulture Research Institute, Agriculture Research Center, Giza, Egypt). The experiment was designed in a randomized complete block design (RCBD) in both seasons with three replications. The seeds of each family were sown in a row of 4 m long, 60 cm apart and

20 cm between hills within rows. Data was collected from 10 guarded plants in each row. The studied traits were:

1. Flowering date (days): Number of days from planting until the first flower appears.
2. Height of plant (cm),
3. Branches plant number,
4. Pods plant number,
5. Length of pod (cm),
6. Pod width (cm),
7. Seed set percentage = Total number of seeds per pods per plant/ Total number of ovules per pods per plant *100,
8. Dry pods weight per plant (g),
9. Dry seed yield per plant (g) and
10. Pod filing percentage = dry seed yield per plant/ dry pods weight per plant.

Phenotypic correlation coefficient ($r_{P(xy)}$) and genotypic correlation coefficient ($r_{G(xy)}$) between two phenotypes (x and y) were calculated as follow:

Phenotypic correlation $r_{P(xy)} = cov_{P(xy)}/(S^2Px \times S^2Py)^{0.5}$

Genotypic correlation $r_{G(xy)} = cov_{G(xy)}/(S^2Gx \times S^2Gy)^{0.5}$

Where:

$cov_{P(xy)}$ = phenotypic covariance between phenotypes x and y

S^2Px = phenotypic variance of phenotype x

S^2Py = phenotypic variance of phenotype y

$cov_{G(xy)}$ = genotypic covariance between phenotypes x and y

S^2Gx = genotypic variance of phenotype x

S^2Gy = genotypic variance of phenotype y

(Falconer 1985)

The Probability of phenotypic correlation coefficient and genotypic correlation coefficient were tested for significance at 0.05 and 0.01 levels of Probability. The correlation analysis with R for Windows (Meta-R Software Package Version 6.03 (Alvarado *et al.,* (2016)) was used to phenotypic and genotypic correlation analysis.

RESULTS AND DISCUSSION

Phenotypic and genotypic correlation between traits in the F_3 generation

The genotypic and phenotypic coefficients correlation between ten studied traits in the F_3 families of the three populations presented in Tables 1, 2 and 3. The estimated genotypic correlation values between studied traits were much higher than their phenotypic correlation values. Genotypic correlation revealed highly negative and significant correlation coefficient between flowering date and pod filing %. Moreover, two positive genotypic correlation coefficient found between height of the plant and number of pod per plant traits and pod length. While, number of pod per plant trait correlated positively and significantly with traits of pod length, pod width, seed set %, dry pods weight / plant and total dry seed yield. Pod width had a positive correlation with dry pod/plant and total dry seed yield with values of (0.795 and 0.607). A negative and significant correlation found between pod filling % and dry pods/ plant traits. On the other correlation coefficient (phenotypic correlation) results revealed that, plant height correlated positively with No. of pods /plant, dry pods weight /plant and total dry seed yield and negatively with pod filing %. Highly positive significant correlation coefficient was found between No. of primary branches /plant and dry pods weight /plant and total dry seed yield /plant. High phenotypic correlation value (r= 0.88) recorded between No. of pods / plant and dry pod weight /plant. A positive correlation (r= 0.981**) was found between dry pods weight/ plant and plant dry seed yield. In the second population correlation analysis revealed that, flowering date related genotypicly and significantly with traits; pods plant number, pod length and pod width with correlation values of 0.482, 0.585 and 0.567, respectively. A strong genotypic correlation found between height of the plant trait and traits plant pods number (r= 0.798) and dry pods weight /plant (r=0.752). A negative genotypic correlation was found between pod width, plant pods number and significant and strong positive genotypic correlation coefficient recorded between total dry seed yield and pod width.

Phenotypic correlation coefficient revealed highly positive significant coefficient between pods plant number and height of plant and plant branches number. Dry pods weight /plant and plant dry seed yield correlated phenotypically with trait; height of plant, branches plant number and pods plant number. Pod filing % had negatively phenotypic correlation with four traits, flowering date, height of plant, length of pod and dry pods weight / plant. However, the estimated phenotypic and genotypic correlation in the third population proved that, Higher and non-expected genotypic value (r= 0.983) was recorded between flowering date and No. of primary branches/ plant. Height of plant height trait correlated phenotypically and significant with length of pod trait and phenotypically and genotypically with dry pods weight and plant dry seed yield. Moreover, dry pods weight /plant and plant dry seed yield /plant traits had a strong genotypically and phenotypically correlation with traits of branches plant number and pods plant number. The correlation between seed yield and the other traits reported by, Asha *et al*., (2020) and Rahman *et al*., (2021) revealed that, pod yield per plant exhibited highly positive and significant character association with number of pods per plant. Similar results for genotypic and phenotypic correlation found by Pal and Singh (2012) magnitudes of genotypic correlation coefficient were higher than their corresponding phenotypic correlation coefficient, this implies, a strong relationship in different pair of characters. The genotypic correlation between flowering date, pod length and pod width also reported by Rahman *et al*., (2019).

Table 1. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients between 10 studied traits in the first F_3 population.

Trait	Flowering date	Height of plant	Plant branches number	Plant pods number	Length of pod	Pod width	Seed set %	Dry pods weight / plant	Plant dry seed yield	Pod filing %
Flowering date		0.019	0.141	0.049	-0.101	0.223	0.258	0.052	-0.1295	-0.898 **
Height of plant	**0.030**		0.446	0.685 **	0.485*	-0.019	0.247	0.274	0.211	-0.677 **
Plant branches number	**0.072**	**0.414****		0.749**	0.062	0.375	- 0.128	0.672**	0.622**	-0.628**
Plant pods number	**0.018**	**0.558****	**0.639****		0.625*	0.769 **	0.621*	0.426	-0.016	0.418
Length of pod	**0.058**	**0.344****	**0.208**	**0.271***		-0.357	-0.411	0.408	-0.483 *	-0.265
Pod width	**0.141**	**0.037**	**0.192**	**0.297***	**-0.224**		0.488	0.795 **	0.607 **	0.036
Seed set %	**-0.116**	**0.192**	**-0.064**	**0.913****	**-0.178**	**0.132**		0.405	0.131	0.187
Dry pods weight / plant,	**-0.002**	**0.621****	**0.587****	**0.88****	**0.210**	**0.339****	**0.322***		0.674 **	-0.449 *
Plant dry seed yield	**-0.068**	**0.580****	**0.532****	**0.501****	**0.165**	**0.345****	**0.362****	**0.981****		0.473 *
Pod filing %	**-0.248**	**-0.482****	**-0.512****	**0.180**	**-0.288***	**-0.065**	**0.123**	**-0.507****	**0.354****	

Where, *, ** are significant and highly significant.

Table 2. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients between 10 studied traits in the second F_3 population.

Trait	Flowering date	Height of plant	Plant branches number	Plant pods number	Length of pod	Pod width	Seed set %	Dry pods weight / plant	Plant dry seed yield	Pod filing %
Flowering date		0.279	0.409	0.482 *	0.583*	0.567 *	0.185	0.319	-0.081	-0.398
Height of plant	**0.155**		0.671 **	0.798 **	0.252	0.442	-0.147	0.752 **	0.347	-0.404
Plant branches number	**0.170**	**0.227**		0.586 *	0.423	-0.055	0.287	0.423*	0.578*	0.181
Plant pods number	**0.052**	**0.463****	**0.468****		0.354	-0.721 **	0.121	0.916**	0.867	-0.032
Length of pod	**0.217**	**0.302***	**0.231**	**0.153**		0.232	0.163	-0.287	0.257	-0.848 **
Pod width	**0.391****	**0.095**	**-0.055**	**-0.124**	**0.091**		-0.268	-0.478	-0.693 **	-0.141
Seed set %	**0.007**	**0.129**	**0.015**	**0.035**	**0.039**	**-0.032**		0.325	0.331	0.087
Dry pods weight / plant,	**0.007**	**0.502****	**0.288***	**0.895****	**0.215**	**-0.133**	**-0.061**		0.944**	-0.319
Plant dry seed yield	**-0.078**	**0.423****	**0.276***	**0.864****	**0.143**	**-0.199**	**-0.042**	**0.954****		0.753 **
Pod filing %	**-0.282***	**-0.334***	**-0.101**	**-0.240**	**-0.297***	**-0.181**	**0.131**	**-0.324***	**-0.036**	

Where, *, ** are significant and highly significant.

Table 3. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients between 10 studied traits in the third F_3 population.

Trait	Flowering date	Height of plant	Plant branches number	Plant pods number	Length of pod	Pod width	Seed set %	Dry pods weight / plant	Plant dry seed yield	Pod filing %
Flowering date		0.276	0.783 **	0.194	-0.116	0.129	0.589*	0.091	0.154	0.401
Height of plant	**0.253**		0.242	0.184	0.162	0.497	0.251	0.757 *	0.769 **	0.183
Plant branches number	**0.497****	**0.226**		0.886 **	0.549	0.417	- 0.098	0.963 **	0.787 **	0.625 *
Plant pods number	**0.138**	**0.329**	**0.584****		0.476	-0.051	- 0.287	0.898 **	0.893 **	-0.215
Length of pod	**-0.146**	**0.016**	**0.061**	**0.264**		0.166	85147	0.959 **	0.951 **	-0.466
Pod width	**0.149**	**0.223**	**0.189**	**0.105**	**0.040**		0.245	-0.145	-0.158	-0.038
Seed set %	**0.371***	**0.094**	**-0.059**	**-0.062**	**-0.138**	**0.115**		0.321	0.128	0.227
Dry pods weight / plant,	**0.111**	**0.454***	**0.594****	**0.853****	**0.399**	**0.139**	**-0.095**		0.999 **	-0.148
Plant dry seed yield	**0.127**	**0.470****	**0.585***	**0.854****	**0.354**	**0.105**	**-0.066**	**0.993****		0.676**
Pod filing %	**0.258**	**0.051**	**-0.098**	**-0.126**	**-0.470****	**-0.265**	**0.147**	**-0.198**	**0.482****	

Where, *, ** are significant and highly significant.

Phenotypic and genotypic correlation between traits in the F_4 generation

The genotypic and phenotypic correlation estimates in the F_4 population's presents in Tables 4, 5 and 6. Same trend found in F_4 the genotypic correlation values were higher than the phenotypic correlation value for the same trait. In population 1results approved that, height of plant trait in population 1 genotypically and phenotypically positive correlated with three traits pods plant number, dry pods weight / plant and plant dry seed yield. Negatively phenotypic and genotypic correlation coefficients were found between pod width and plant branches number and pods plant number. While, in the second population flowering date had a genotypic and phenotypic significant correlation with pod width trait. The same correlation results found in Pop.2 like which found in Pop.1, significant and positive phenotypic and genotypic correlation between five studied traits; dry pod weight /plant, plant dry seed yield, height of plant, branches plant number and pods plant number. Pod width trait was genotypically and positively correlated with seed set % and negatively phenotypically with same trait. Meanwhile, correlation estimates in population three showed that, a significant and genotypic correlation coefficient found among three traits branches plant number, height of plant and flowering date. Flowering date had a phenotypic correlation with six traits, height of plant, branches plant number, pods plant number, seed set %, dry pods weight /plant and plant dry seed yield. A positively and significant phenotypic relation found between dry pods weight /plant, plant dry seed yield, flowering date, height of plant, branches plant number, pods plant number were. The estimated values of genotypic correlation between the most of traits in the studied pea populations were higher than their phenotypic correlation values this this implies, a strong relationship in different pair of characters. Similar results reported by (Pal and Singh (2012), Georgieva *et al*., (2015) and Singh *et al*., (2016)). The correlation between plant dry seed yield and other traits like height of plant, plant branches number, plant pods number, length of pod and pod weight was highly significant and positive. This results is matches the results found by, Siddika *et al*., (2013) Singh *et al*., (2018), Ali *et al*. (2021), Gupta *et al*., (2020), Asha *et al*., (2020) and Rahman *et al*., (2021). Thus, traits of height of plant, plant branches number, plant pods number, length of pod and number of seed per pod (pod filing percentage), were found to be the most vital component characters and positively associated with plant dry seed yield.

Table 4. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients between 10 studied traits in the first F_4 population .

Trait	Flowering date	Height of plant	Plant branches number	Plant pods number	Length of pod	Pod width	Seed set %	Dry pods weight / plant	Plant dry seed yield	Pod filing %
Flowering date		0.291	0.022	0.322	0.216	0.062	0.141	0.027	-0.015	-0.326
Height of plant	**0.190**		-0.376	0.571 **	0.020	-0.118	0.247	0.557 **	0.545 **	0.061
Plant branches number	**-0.062**	**0.010**		0.229	0.310	-0.647 **	- 0.322	0.308	0.359	0.415*
Plant pods number	**0.177**	**0.559****	**0.198**			-0.447*	0.431	0.803 **	0.788 **	0.201
Length of pod	**0.208**	**0.087**	**0.176**	**0.127**		-0.296	0.131	0.227	0.196	-0.058
Pod width	**0.085**	**-0.035**	**-0.264***	**-0.253***	**-0.213**		0.259	-0.321	-0.338	0.274
Seed set %	**0.023**	**0.163**	**-0.134**	**0.228**	**0.081**	**0.151**		0.121	0.221	0.047
Dry pods weight / plant,	**0.006**	**0.549****	**0.294***	**0.819****	**0.267***	**-0.209**	**0.128**		0.989 **	0.293
Plant dry seed yield	**-0.033**	**0.514****	**0.294***	**0.794****	**0.242***	**-0.234**	**0.097**	**0.983***		0.426
Pod filing %	**-0.262***	**-0.128**	**0.056**	**-0.003**	**-0.078**	**-0.191**	**-0.139**	**0.052**	**0.229**	

Where, *, ** are significant and highly significant.

Table 5. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients between 10 studied traits in the second F_4 population .

Trait	Flowering date	Height of plant	Plant branches number	Plant pods number	Length of pod	Pod width	Seed set %	Dry pods weight / plant	Plant dry seed yield	Pod filing %
Flowering date		0.025	-0.130	0.023	-0.089	0.638 **	0.614*	0.136	0.202	0.546 *
Height of plant	**0.055**		0.699 **	0.646 **	0.136	-0.295	- 0.144	0.601 *	0.568 *	-0.051
Plant branches number	**-0.048**	**0.217**		0.785 **	-0.076	-0.389	-0.460	0.961 **	0.801 **	-0.083
Plant pods number	**0.008**	**0.516****	**0.510****		-0.240	-0.259	0.051	0.901 **	0.858 **	-0.019
Length of pod	**-0.108**	**0.057**	**-0.130**	**-0.143**		-0.252	0.258	0.115	0.102	-0.054
Pod width	**0.491****	**-0.157**	**-0.162**	**-0.300** *	**-0.033**		0.178	-0.328	-0.324	-0.095
Seed set %	**0.186**	**0.053**	**-0.325***	**0.067**	**0.101**	**-0.033**		0.221	0.321	0.187
Dry pods weight / plant,	**0.083**	**0.529****	**0.443****	**0.907****	**0.020**	**-0.310**	**0.161**		0.993 **	0.360
Plant dry seed yield	**0.116**	**0.516****	**0.431****	**0.879****	**0.005**	**-0.293***	**0.147**	**0.989****		0.472
Pod filing %	**0.189**	**0.005**	**0.019**	**0.018**	**-0.060**	**-0.022**	**-0.083**	**0.155**	**0.294***	

Where, *, ** are significant and highly significant.

Table 6. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients between 10 studied traits in the third F_4 population .

Trait	Flowering date	Height of plant	Plant branches number	Plant pods number	Length of pod	Pod width	Seed set %	Dry pods weight / plant	Plant dry seed yield	Pod filing %
Flowering date		0.502	0.677 **	0.513	0.162	-0.159	0.745**	0.492	0.500	0.303
Height of plant	**0.338***		0.654**	0.798 **	0.243	-0.235	0.109	0.835**	0.835**	0.502
Plant branches number	**0.383****	**0.370***		0.695**	-0.811**	-0.497	0.221	0.741**	0.796 **	0.879**
Plant pods number	**0.355***	**0.740****	**0.414** **		-0.008	-0.161	0.087	0.789**	0.824**	0.659**
Length of pod	**0.124**	**0.265**	**-0.069**	**0.075**		-0.603*	-0.471	-0.200	0.324	0.389
Pod width	**-0.136**	**-0.050**	**0.012**	**-0.061**	**-0.363***		-0.2	-0.076	-0.078	-0.118
Seed set %	**0.347***	**-0.005**	**0.150**	**-0.072**	**-0.344***	**0.031**		0.265	0.201	-0.321
Dry pods weight / plant,	**0.334***	**0.711****	**0.462****	**0.955****	**0.129**	**-0.041**	**-0.044**		0.994**	0.613*
Plant dry seed yield	**0.365***	**0.706****	**0.432****	**0.953****	**0.229**	**-0.059**	**-0.054**	**0.990****		0.694**
Pod filing %	**0.291**	**0.237**	**-0.042**	**0.356***	**0.199**	**-0.182**	**-0.120**	**0.322***	**0.450***	

Where, *, ** are significant and highly significant.

CONCLUSION

This work approved that selection for one trait or more traits of height of the plant, plant branches number, plant pods number, length of pod, pod filing percentage considered a direct selection for the plant dry seed yield trait.

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