



## Adaptability and Phenotypic Stability of Newly Released Pea Genotypes

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### ABSTRACT

Twelve promising genotypes of pea were evaluated under three environments (Kaliobia, Sohag and New-Valley) during two successive winter seasons (2021/2022 and 2022/2023) to estimate the parameters of genetic and phenotypic stability of some promising lines of pea with some cultivars widespread in Egyptian agriculture under three different climatic environments. The results showed that the lines No. 1, 2, 3 and 4 had the highest values in fresh pods yield (ton fed<sup>-1</sup>) compared with the other lines or the check cultivars. Highly significant mean squares attributable to genotypes, environments, and genotypes environment interactions were found for all the characteristics under study, indicating that the genotypes may respond differently from one environment and year to the another. The stability parameters (bi and S<sup>2</sup>d) for fresh pods yield (ton fed<sup>-1</sup>) showed that about five genotypes tended to be stable across the studied environments. The regression coefficient (bi) and the deviation from the regression (S<sup>2</sup>d) both had insignificant stability parameters from unity and from zero. Lines No. 1, 2, 3 and 4 with a regression coefficient (bi>1) that is above average, potentially generate higher yield when environments are favorable and there is fertile soil, enough water, and other inputs. Four out of twelve genotypes had the highest fresh pods weight (ton fed<sup>-1</sup>) over all genotypes. These genotypes were line No. 1 (4.557 ton fed<sup>-1</sup>), line No. 2 (4.764 ton fed<sup>-1</sup>), line No. 3 (4.135 ton fed<sup>-1</sup>) and line No. 4 (4.901 ton fed<sup>-1</sup>) and in the regions under study, they might be suggested for cultivation and given unique names as cultivars.

**Key words:** Environment, Genotype, Pea, Regression coefficient, Stability

### INTRODUCTION

In Egypt, the pea (*Pisum sativum* L.) is an essential cool-season vegetable crop. This plant is mainly cultivated for human consumption, though it may also be feed to livestock. Additionally, if correctly managed, it complements well within cereal rotations as a legume crop to add nitrogen to the soil and reduce the impact of diseases in non-legume crops (Ceyhan et al., 2012). Fresh seeds are rich in nutrients, especially minerals and vitamins. Each 100 g of raw pea contains 78.0 g water, 84 calories, 6.3 g protein, 0.4 g fats, 14.4 g total carbohydrates, 2.0 g fibers, 26 mg calcium, 116 mg phosphorus, 1.9 mg iron, 316 mg potassium, 640 IU of vitamin A, 0.35 mg niacin (nicotinic acid), and 27 mg ascorbic acid (Watt and Merrill, 1963). Many of Egyptian authors such as El-Dakkak, 2005, El-Dakkak et al., 2009, Hussein and El-Dakkak, 2009 and Hussein et al., 2009 were study of the genetic performance of pea grown in Upper Egypt, genetic variations represent around 78% of phenotypic variations.

Therefore, it would be able to further develop these features since they may be more phenotypically predominant. Increases in fresh pod yield and pods/plant were recorded. Accepting any new pea cultivars now primarily requires easiness and good yield potential. Earliness and high yield potential became a main requirement for accepting any new pea cvs. Pea is significantly impacted by seasonal and other environmental variations and exhibits high genotype-environment interaction (G-E), which poses a significant obstacle to knowing the full extent of genetic regulation of different varieties when compared across various environments. When the ranks of genotypes clearly change from one environment to another, this is another indication of GE interaction. It is crucial to recognize predictable environmental variation in order to limit the size of G-E interactions and facilitate breeding programmes. Genotype-environment (G-E) interaction lowers the association between phenotypic



and genotypic expression and may make selections that do well in one environment perform poorly in another. In order to choose the best breeding plan and release genotypes that are sufficiently adapted to the target environments, measuring (G-E) interactions is also crucial. The fundamental indicator of stability is the G-E interaction; To derive genotypic stability factors from the G-E interaction, many strategies have been used. Hazra et al., (1999), Sharma (1999), Sharma et al., (2000), Padi (2004), and Lal et al., (2010) are several authors who investigated genetic gain in cowpea, the results of testing fifteen genotypes at five different sites revealed that the genotype (G) environment (E) interaction and both genotype and environment-related variances were significant. G and E interaction was split into linear and non-linear components, indicating that both predictable and unpredictable components shared the interaction. The superior and stable genotype

was assessed using three stability measures. The yield response and stability of cowpea genotypes were examined by Shiringani and Shimelis (2011) at three planting dates and test conditions. They discovered significant interactions (P 0.01) for seed yield among the genotypes, planting dates, and locations. The three genotypes with the highest stable yielding were suitable for cultivation in these or other comparable settings in South Africa. Stability is of great importance in selecting genotypes for different growing systems and environmental conditions (Arif, et al., 2020 and Vafias, et al., 2007). The main target of the current research was to investigate the yield and its component performance and stability criteria in some pea genotypes under six locations (combinations of 2 years - 3 locations) in order to determine the best genotypes for developing new garden pea cultivars with high yields and desirable traits.

## MATERIALS AND METHODS

Ten new promising lines of pea and two marketed cultivars were subjected to evaluation in six various environments. The pea breeding programme of Horticulture Research Institute produced advanced lines (El-Dakkak, 2005, El-Dakkak et al., 2009, Hussein and El-Dakkak, 2009 and Hussein et al., 2009). These environments were resulted from combinations of two years (2021/2022 and 2022/2023 winter seasons) with three locations, i.e. Kaliobia, Sohag and the New-Valley. Each experiment had three replications and was set up using a randomized complete blocks design. Six rows, each 3 m long and 50 cm apart, of each genotype were sowed. Planting were done in hills spaced 10 cm apart within rows. After full emergence the seedlings were thinned to two plants per hill. Planting dates were October 15<sup>th</sup> at all locations in both 2021/2022 and 2022/2023 growing seasons. Data were recorded on flowering date, plant height, pod length (cm), number of pods/plant, number of seeds/pod, fresh pods weight (g plant<sup>-1</sup>), fresh seeds weight (g plant<sup>-1</sup>) and fresh pods yield (ton fed<sup>-1</sup>).

The genotype by environment interaction effects as described by Snedecor and Cochran (1967) were detected using combined analysis of variance across the six environments (two years and three locations). According to Eberhart and Russell (1966), a statistical analysis was performed on the data for each attribute as the following equation:  $Y_{ij} = \mu + \beta_i I_j + \delta_{ij}$  Where:

$Y_{ij}$ ; represents the average yield of the  $i^{\text{th}}$  genotype in the  $j$  environments (where  $i = 1, 2, 3 \dots v$  and  $j = 1, 2 \dots n$ ).

$\mu$ ; is the average genotype for a given environment.

$\beta_i$ ; is the regression coefficient of the  $i^{\text{th}}$  genotype's measured response to various environments.  $b_i = \sum_j Y_{ij} I_j / \sum_j I_j^2$

$I_j$ ; is the environmental index obtained as the mean of all genotypes at the  $j^{\text{th}}$  environment minus the grand mean.

$[I_j = (\sum_i Y_{ij} / v) - (\sum_i \sum_j Y_{ij} / vn)], \sum_j I_j = 0$

$\delta_{ij}$ ; is the deviation of the  $i^{\text{th}}$  genotype from regression at the  $j^{\text{th}}$  environment.

$$S^2_d = [\sum_j \delta_{ij}^2 / (n-2)] - s^2_e / r$$

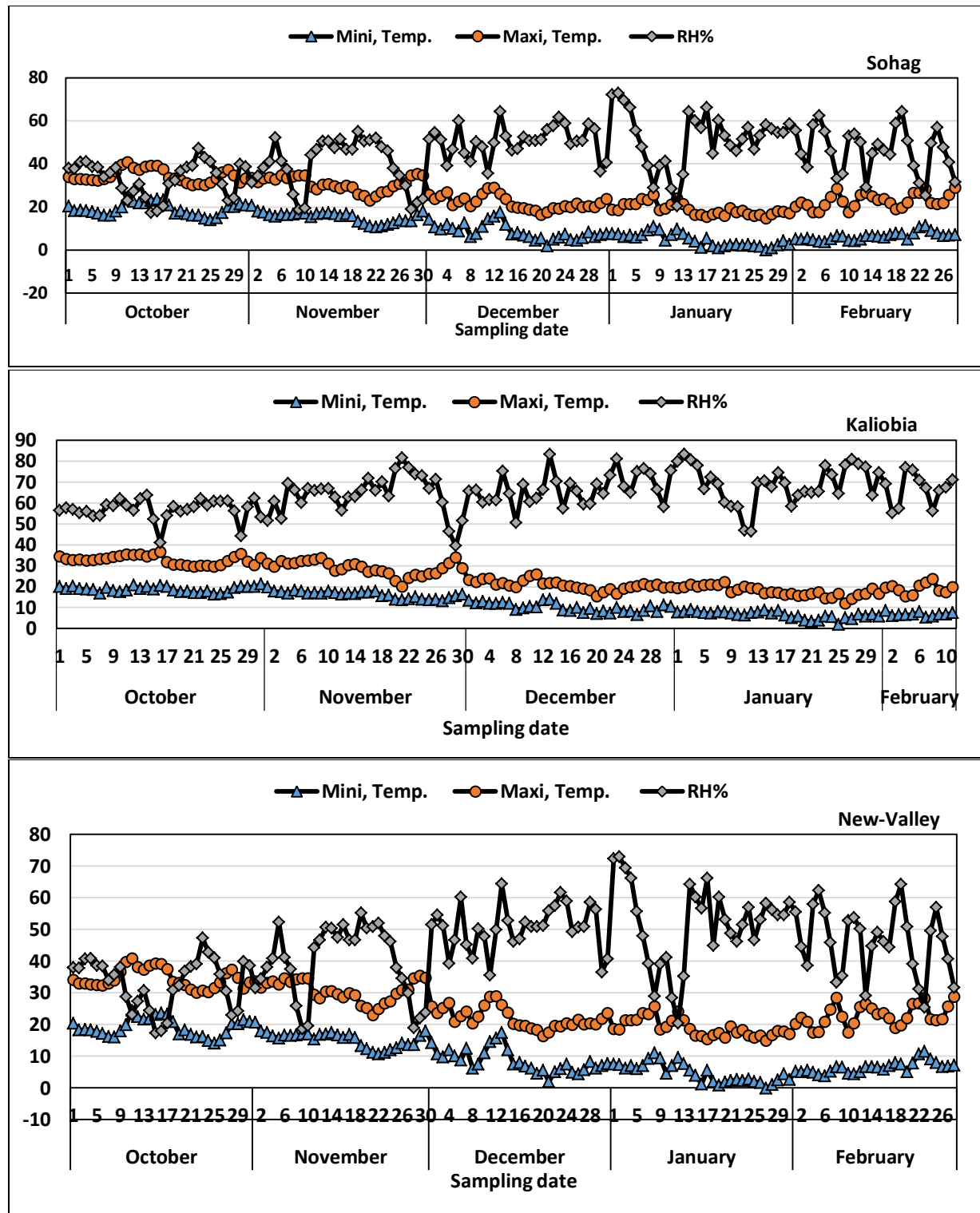


Fig (1): Minimum and maximum values of air temperature and relative humidity through 2021/2022 winter season in Sohag, Kaliobia and New-Valley Governorates.

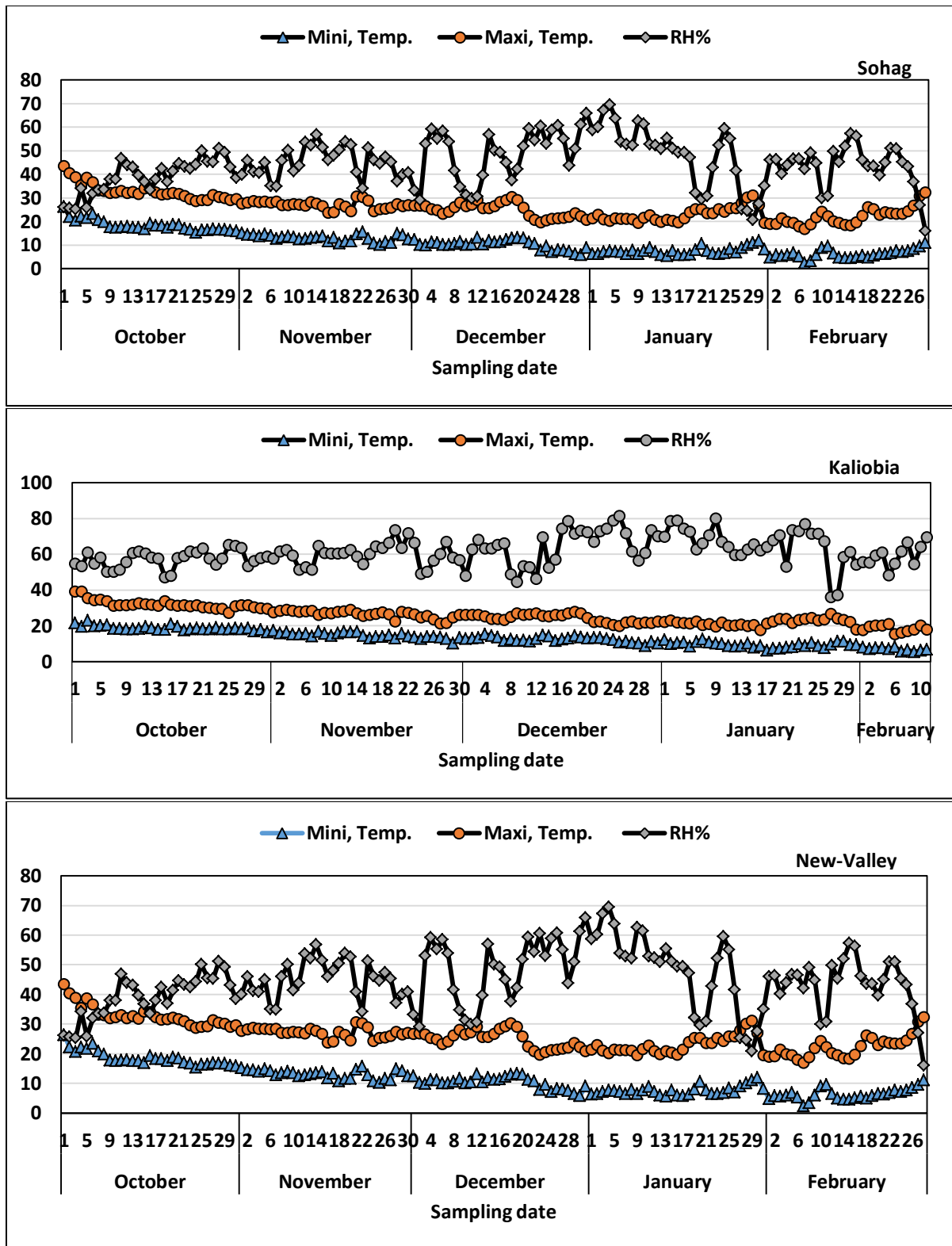


Fig (2): Minimum and maximum values of air temperature and relative humidity through 2022/2023 winter season in Sohag, Kaliobia and New-Valley Governorates.



## RESULTS AND DISCUSSIONS

### Analysis of variance:

All of the examined traits had significant genotype (G) and environment (E) variations, according to a combined analysis of the data. Genotype × environment (G×E) interaction variance was highly significant for the most studied traits, indicating the impact of environments in the expression of these traits in pea genotypes (Tables, 1 & 2). These findings are in harmony with those found by Hazra, et al., (1999), Sharma (1999), Sharma, et al., (2000), Padi (2004) and Yousaf, Sarwar (2008), Hamed et al., (2017), Heba, et al., (2019) and Greveniotis, et al., (2023).

Other researchers have examined the significance of genotype by environment interaction in regional variety trials or in selection for extensive adaptability (Becker

and Leon 1988, Crossa et al., 1990, and Cooper and Dalecy 1994). Several researchers have noted the existence of substantial genotypic variations in pea for yield and agronomic criteria, including Damarany (1994), Ishiyaku et al., (2005), Sarvamangala, et al., (2010), Hamed, et al., (2017), Heba, et al., (2019), and Greveniotis, et al., (2023). The majority of studies, however, were carried out in a single site or in a controlled environment, which may have understated the environmental effect and the genotype by environment interaction.

Therefore, the stability analysis could be performed to estimate the overall performance and adaptation of the genotypes.

**Table (1). Mean squares of combined analysis of variance years and locations for flowering date, plant height, pod length and number of pods/plant of 12 pea genotypes.**

| S.O.V            | d.f | Flowering date | Plant height (cm) | Pod length (cm) | Number of pods/ plant |
|------------------|-----|----------------|-------------------|-----------------|-----------------------|
| Year (Y)         | 1   | 0.375          | 1276.042**        | 1.965**         | 729.671**             |
| Environments (E) | 2   | 15.199**       | 131.866**         | 2.207**         | 43.792**              |
| Y x E            | 2   | 0.347          | 1.792             | 0.066           | 4.31*                 |
| EY (r-1)         | 12  | 1.185          | 3.282             | 0.053           | 0.806                 |
| Genotypes(G)     | 11  | 341.348**      | 4260.873**        | 12.11**         | 227.668**             |
| Y x G            | 11  | 52.678**       | 50.153**          | 1.285**         | 76.146**              |
| E x G            | 22  | 2.138**        | 1.568             | 0.12**          | 1.191                 |
| Y x E x G        | 22  | 1.802**        | 1.039             | 0.082           | 0.679                 |
| Error            | 132 | 1.18           | 2.101             | 0.07            | 1.341                 |

**Table (2). Mean squares of combined analysis of variance years and locations for number of seeds/pod, fresh pods weight/plant, fresh seeds weight/plant and fresh pods weight/feddan of 12 pea genotypes.**

| S.O.V            | d.f | Number of seeds/pod | Fresh pods weight (g plant <sup>-1</sup> ) | Fresh seeds weight (g plant <sup>-1</sup> ) | Fresh pods weigh (ton fed-1) |
|------------------|-----|---------------------|--|---|------------------------------|
| Year (Y)         | 1   | 11.207**            | 21.806**                                   | 0.239                                       | 0.055                        |
| Environments (E) | 2   | 0.434**             | 5481.128**                                 | 1377.199**                                  | 13.703**                     |
| Y x E            | 2   | 0.036               | 82.975**                                   | 27.313**                                    | 0.208**                      |
| EY (r-1)         | 12  | 0.112               | 7.497                                      | 2.422                                       | 0.019**                      |
| Genotypes(G)     | 11  | 11.835**            | 3893.616**                                 | 733.129**                                   | 9.734                        |
| Y x G            | 11  | 0.441**             | 17.008**                                   | 5.787*                                      | 0.043**                      |
| E x G            | 22  | 0.02                | 16.905**                                   | 6.839**                                     | 0.042**                      |
| Y x E x G        | 22  | 0.01                | 1.26                                       | 0.292                                       | 0.003                        |
| Error            | 132 | 0.056               | 2.131                                      | 2.472                                       | 0.005                        |

\*, \*\* significant and highly significant at 0.05 and 0.01 levels of probability, respectively.





**Table (3). Mean squares of combined analysis of variance for flowering date, plant height, pod length and number of pods/plant.**

| S.O.V            | d.f | Flowering date | Plant height | Pod length (cm) | Number of pods/ plant |
|------------------|-----|----------------|--------------|-----------------|-----------------------|
| Environments (E) | 5   | 6.294**        | 308.671**    | 1.302**         | 165.175**             |
| R (E)            | 12  | 1.185          | 3.282        | 0.053           | 0.806                 |
| Genotypes (G)    | 11  | 341.348**      | 4260.873**   | 12.11**         | 227.668**             |
| E v G.           | 55  | 12.112&&       | 11.073**     | 0.338**         | 15.977**              |
| Error            | 132 | 1.18           | 2.101        | 0.07            | 1.341                 |

**Table (4). Mean squares of combined analysis of variance for number of seeds/pod, fresh pods weight (g plant<sup>-1</sup>), fresh seeds weight (g plant<sup>-1</sup>) and fresh pods weight (ton /fed.<sup>-1</sup>),**

| S.O.V            | d.f | Number of seeds/pod | Fresh pods weight (g plant <sup>-1</sup> ) | Fresh seeds weight (g plant <sup>-1</sup> ) | Fresh pods weigh (ton fed <sup>-1</sup> ) |
|------------------|-----|---------------------|--|---|---|
| Environments (E) | 5   | 2.429**             | 2230.003**                                 | 561.853**                                   | 5.575**                                   |
| R (E)            | 12  | 0.112               | 7.497                                      | 2.422                                       | 0.019                                     |
| Genotypes (G)    | 11  | 11.835**            | 3893.616**                                 | 733.129**                                   | 9.734**                                   |
| E v G.           | 55  | 0.100**             | 10.667**                                   | 4.01*                                       | 0.027**                                   |
| Error            | 132 | 0.056               | 2.131                                      | 2.472                                       | 0.005                                     |

\*, \*\* significant and highly significant at 0.05 and 0.01 levels of probability, respectively.

Data in Tables (5 & 6) demonstrated that for all examined traits, the linear response of environments was very important. As a consequence of this, the regression coefficient (bi) and deviation from regression (S<sup>2</sup>d) for each genotype were determined and averaged across the six settings (Tables 7, 8 & 9). Since genotypes

varied in how they regressed on the environmental index, the significance of GE (linear) enables us to proceed and estimate bi values. However, the significance of the E + (GE) interaction reveals that the six environmental factors and genotypes interacted significantly.

**Table (5). Stability analysis of variance for flowering date, plant height, pod length and number of pods/plant of 12 pea genotypes evaluated under six different environmental conditions.**

| S.O.V            | d.f | Mean squares         |                      |                       |                        |
|------------------|-----|----------------------|----------------------|-----------------------|------------------------|
|                  |     | Flowering date       | Plant height (cm)    | Pod length (cm)       | Number of pods/ plant  |
| Genotypes (G)    | 11  | 341.302**            | 4260.59**            | 12.1256**             | 227.6467**             |
| G.x E            | 60  | 11.624**             | 35.874**             | 0.41893 <sup>NS</sup> | 28.41211**             |
| E (linear)       | 1   | 31.568**             | 1543.49**            | 6.52412**             | 826.0592**             |
| G.xE (linear)    | 11  | 2.1004**             | 40.106**             | 0.50704*              | 68.49718**             |
| Pooled deviation | 48  | 13.391**             | 3.4954**             | 0.27154 <sup>NS</sup> | 2.6083**               |
| Line No. 1       | 4   | 1.1584**             | 0.4657 <sup>NS</sup> | 0.41587 <sup>NS</sup> | 0.584013**             |
| Line No. 2       | 4   | 3.6519**             | 2.2008**             | 0.01376 <sup>NS</sup> | 3.904543**             |
| Line No. 3       | 4   | 4.0962**             | 6.8068**             | 0.05011 <sup>NS</sup> | 4.56444**              |
| Line No. 4       | 4   | 20.661**             | 4.0728**             | 0.05492 <sup>NS</sup> | 4.470864**             |
| Line No. 5       | 4   | 17.681**             | 1.3622**             | 0.00997 <sup>NS</sup> | 1.382864**             |
| Line No. 6       | 4   | 4.2215**             | 0.75650*             | 0.44131 <sup>NS</sup> | 4.340877**             |
| Line No. 7       | 4   | 3.9029**             | 0.2824 <sup>NS</sup> | 0.05424 <sup>NS</sup> | 2.764988**             |
| Line No. 8       | 4   | 78.939**             | 2.07359**            | 1.92685**             | 3.52701**              |
| Line No. 9       | 4   | 6.2331**             | 5.07816**            | 0.17245 <sup>NS</sup> | 0.587284**             |
| Line No. 10      | 4   | 0.2067 <sup>NS</sup> | 4.89794**            | 0.05571 <sup>NS</sup> | 1.295547**             |
| Sweet-1          | 4   | 19.3028**            | 11.4586**            | 0.04348 <sup>NS</sup> | 0.506539 <sup>NS</sup> |
| Super-1          | 4   | 0.6387*              | 2.4892**             | 0.01984 <sup>NS</sup> | 3.370635**             |
| Pooled Error     | 132 | 1.18                 | 2.101                | 0,07                  | 1.341                  |



**Table (6). Stability analysis of variance for number of seeds/pod, fresh pods weight (g plant<sup>-1</sup>), fresh seeds weight (g plant<sup>-1</sup>) and fresh pods weight (ton fed.<sup>-1</sup>) of 12 pea genotypes evaluated under six different environmental conditions.**

| S.O.V                   | d.f        | Mean squares           |  |   |  |
|-------------------------|------------|------------------------|--|---|--|
|                         |            | Number of seeds/pod    | Fresh pods weight (g plant <sup>-1</sup> ) | Fresh seeds weight (g plant <sup>-1</sup> ) | Fresh pods weight (ton fed <sup>-1</sup> ) |
| <b>Genotypes (G)</b>    | <b>11</b>  | 11.83651**             | 3893.547**                                 | 733.2324**                                  | 9.7349**                                   |
| <b>G.x E</b>            | <b>60</b>  | 0.29418 <sup>NS</sup>  | 195.6095**                                 | 50.50097**                                  | 0.4890 <sup>NS</sup>                       |
| <b>E (linear)</b>       | <b>1</b>   | 12.1208**              | 11149.91**                                 | 2809.574**                                  | 27.8717**                                  |
| <b>G.xE (linear)</b>    | <b>11</b>  | 0.401654 <sup>NS</sup> | 32.11435**                                 | 13.00994**                                  | 0.0803 <sup>NS</sup>                       |
| <b>Pooled deviation</b> | <b>48</b>  | 0.023163 <sup>NS</sup> | 4.862478**                                 | 1.611965**                                  | 0.0121 <sup>NS</sup>                       |
| <b>Line No. 1</b>       | <b>4</b>   | 0.035107 <sup>NS</sup> | 16.13554**                                 | 2.258081**                                  | 0.0405 <sup>NS</sup>                       |
| <b>Line No. 2</b>       | <b>4</b>   | 0.015494 <sup>NS</sup> | 3.121745**                                 | 0.164459 <sup>NS</sup>                      | 0.0078 <sup>NS</sup>                       |
| <b>Line No. 3</b>       | <b>4</b>   | 0.001891 <sup>NS</sup> | 4.880235**                                 | 0.933895**                                  | 0.0122 <sup>NS</sup>                       |
| <b>Line No. 4</b>       | <b>4</b>   | 0.069247 <sup>NS</sup> | 2.233202**                                 | 10.52245**                                  | 0.0056 <sup>NS</sup>                       |
| <b>Line No. 5</b>       | <b>4</b>   | 0.018423 <sup>NS</sup> | 22.22735**                                 | 3.046896**                                  | 0.0553 <sup>NS</sup>                       |
| <b>Line No. 6</b>       | <b>4</b>   | 0.005338 <sup>NS</sup> | 3.038592**                                 | 0.018228 <sup>NS</sup>                      | 0.0075 <sup>NS</sup>                       |
| <b>Line No. 7</b>       | <b>4</b>   | 0.025908 <sup>NS</sup> | 4.318754**                                 | 0.765065*                                   | 0.0108 <sup>NS</sup>                       |
| <b>Line No. 8</b>       | <b>4</b>   | 0.008237 <sup>NS</sup> | 0.223386 <sup>NS</sup>                     | 0.685122*                                   | 0.0006 <sup>NS</sup>                       |
| <b>Line No. 9</b>       | <b>4</b>   | 0.009689 <sup>NS</sup> | 0.494785 <sup>NS</sup>                     | 0.131383 <sup>NS</sup>                      | 0.0012 <sup>NS</sup>                       |
| <b>Line No. 10</b>      | <b>4</b>   | 0.043205 <sup>NS</sup> | 0.1263 <sup>NS</sup>                       | 0.010993 <sup>NS</sup>                      | 0.0003 <sup>NS</sup>                       |
| <b>Sweet-1</b>          | <b>4</b>   | 0.010921 <sup>NS</sup> | 0.611629*                                  | 0.090532 <sup>NS</sup>                      | 0.0015 <sup>NS</sup>                       |
| <b>Super-1</b>          | <b>4</b>   | 0.034492 <sup>NS</sup> | 0.938218**                                 | 0.716466*                                   | 0.0024 <sup>NS</sup>                       |
| <b>Pooled Error</b>     | <b>132</b> | 0.056                  | 2.131                                      | 2.472                                       | 0.005                                      |

\*, \*\* significant and highly significant at 0.05 and 0.01 levels of probability, respectively

**Estimates of stability parameters**

For some genotypes, such as both lines No. 1, 3 and 4 for the most studied traits, the regression coefficient (bi) values were significant and greater than one (bi > 1), indicating high potential response for these genotypes in favorable environments (Tables 7, 8 & 9) and (Fig. 3). On the other hand, for 4 genotypes in at least one of the most investigated traits, such as Line No. 7 for all examined traits, the regression coefficient was significant but less than 1 (bi). These genotypes exhibited an increase in productivity in unfavorable conditions. For the growing of common beans in less favorable environments, Hamed, et al., (2017), Heba, et al., (2019) and Greveniotis, et al., (2023) identified various genotypes to take into consideration as standard cultivars. For all of the examined variables, the various genotypes did not show a consistent pattern of responsiveness or stability. Within a single genotype, the stability and responsiveness appeared to be specific for specific characters. On the other hand, in

some genotypes for some features, the value of "bi" reached or was nearby unity, indicating an average response to the varying environmental conditions that existed at the various locations across years. As shown in the results in Tables (7, 8 & 9), some genotypes for particular traits had significant levels of deviation from regression (S<sup>2</sup>d), indicating the instability of these genotypes with respect to those traits. It should be noted that a genotype's performance can be predicted and is considered stable if it has a non-significant deviation from regression (S<sup>2</sup>d=0) or non-significant regression coefficients (bi=1) (Eberhart and Russell 1966). In accordance with Jatasra and Paroda (1980), the deviation from the regression line (S<sup>2</sup>d) is the best indicator of stability whereas linear regression can be used to evaluate the response of a specific genotype. Therefore, the most stable phenotypes are those with the lowest insignificant deviation from regression, and *vice versa*.



**Table (7). Estimates of stability for flowering date, plant height and pod length (cm) of 12 pea genotypes grown under different environments.**

| No.                       | Genotypes   | Flowering date |         |                     | Plant height (cm) |                     |                     | Pod length (cm) |                     |                     |
|---------------------------|-------------|----------------|---------|---------------------|-------------------|---------------------|---------------------|-----------------|---------------------|---------------------|
|                           |             | $\bar{X}$      | $b_i$   | $S^2d$              | $\bar{X}$         | $b_i$               | $S^2d$              | $\bar{X}$       | $b_i$               | $S^2d$              |
| 1                         | Line No. 1  | 46.11          | 1.864*  | 1.16**              | 61.11             | 1.224**             | 0.466 <sup>NS</sup> | 11.16           | 2.785**             | 0.416 <sup>NS</sup> |
| 2                         | Line No. 2  | 49.11          | 1.571   | 3.65**              | 71.61             | 1.556**             | 2.201**             | 10.48           | 0.491 <sup>NS</sup> | 0.014 <sup>NS</sup> |
| 3                         | Line No. 3  | 45.67          | 0.937   | 4.01**              | 63.28             | 1.735**             | 6.807**             | 10.60           | 0.833 <sup>NS</sup> | 0.050 <sup>NS</sup> |
| 4                         | Line No. 4  | 49.44          | 0.386   | 20.66**             | 75.33             | 1.669**             | 4.073**             | 10.41           | 0.510 <sup>NS</sup> | 0.055 <sup>NS</sup> |
| 5                         | Line No. 5  | 51.72          | 0.925   | 17.68**             | 78.17             | 1.304**             | 1.362**             | 9.85            | 1.000 <sup>NS</sup> | 0.010 <sup>NS</sup> |
| 6                         | Line No. 6  | 52.67          | 0.955   | 4.222**             | 81.89             | 1.268**             | 0.757**             | 10.02           | 0.467 <sup>NS</sup> | 0.441 <sup>NS</sup> |
| 7                         | Line No. 7  | 56.33          | 0.647   | 3.903**             | 61.72             | 0.744**             | 0.282 <sup>NS</sup> | 9.06            | 0.546 <sup>NS</sup> | 0.054 <sup>NS</sup> |
| 8                         | Line No. 8  | 49.17          | 2.841** | 78.94**             | 59.33             | 0.507*              | 2.074**             | 9.13            | 3.238**             | 1.927**             |
| 9                         | Line No. 9  | 45.56          | 1.444   | 6.233**             | 81.45             | 0.128 <sup>NS</sup> | 5.078**             | 8.90            | 0.773 <sup>NS</sup> | 0.172 <sup>NS</sup> |
| 10                        | Line No. 10 | 43.50          | 0.623   | 0.207 <sup>NS</sup> | 88.72             | 1.152**             | 4.898**             | 8.72            | 0.197 <sup>NS</sup> | 0.056 <sup>NS</sup> |
| 11                        | Sweet-1     | 40.06          | -0.825  | 19.30**             | 29.95             | 0.387 <sup>NS</sup> | 11.45**             | 10.87           | 0.597 <sup>NS</sup> | 0.043 <sup>NS</sup> |
| 12                        | Super-1     | 47.28          | 0.632   | 0.639*              | 68.50             | 0.327 <sup>NS</sup> | 2.489**             | 10.21           | 0.563 <sup>NS</sup> | 0.020 <sup>NS</sup> |
| <b>Mean</b>               |             | <b>48.05</b>   | --      | --                  | <b>68.42</b>      | --                  | --                  | <b>9.95</b>     | --                  | --                  |
| <b>LSD<sub>0.05</sub></b> |             | <b>2.46</b>    | --      | --                  | <b>2.76</b>       | --                  | --                  | <b>0.44</b>     | --                  | --                  |

The findings in (Tables, 7, 8 & 9) showed that the majority of the genotypes used had non-significant values of deviation from regression ( $S^2d$ ), demonstrating the stability of these genotypes with respect to this feature. Others demonstrated specialized adaptation to either favorable or unfavorable circumstances. Some genotypes indicated wide adaptation. The results showed that lines 1, 2, 3, and 4 produced the highest

mean yields of fresh pods weight (4.557, 4.764, 4.135 and 4.901 tons fed.<sup>-1</sup>, respectively) across all environments, with regression coefficients ( $b_i$ ) close to unity and deviation from regression ( $S^2d$ ) not significantly different from zero. These findings demonstrated a high yielding performance based on wide adaptability and performance stability across various environments.

**Table (8). Estimates of stability for number of pods/plant, number of seeds/pod and fresh pods weight (g plant<sup>-1</sup>) of 12 pea genotypes grown under different environments.**

| No.                       | Genotypes   | Number of pods/plant |                      |                     | Number of seeds/pod |                     |                     | Fresh pods weight (g plant <sup>-1</sup> ) |                     |                     |
|---------------------------|-------------|----------------------|----------------------|---------------------|---------------------|---------------------|---------------------|--|---------------------|---------------------|
|                           |             | $\bar{X}$            | $b_i$                | $S^2d$              | $\bar{X}$           | $b_i$               | $S^2d$              | $\bar{X}$                                  | $b_i$               | $S^2d$              |
| 1                         | Line No. 1  | 27.00                | 1.089**              | 0.584*              | 8.40                | 1.099 <sup>NS</sup> | 0.035 <sup>NS</sup> | 91.13                                      | 1.218**             | 16.14**             |
| 2                         | Line No. 2  | 25.50                | -0.113 <sup>NS</sup> | 3.905**             | 7.65                | 0.376 <sup>NS</sup> | 0.015 <sup>NS</sup> | 95.29                                      | 1.257**             | 3.122**             |
| 3                         | Line No. 3  | 29.33                | 2.723**              | 4.564**             | 7.65                | 1.374 <sup>NS</sup> | 0.002 <sup>NS</sup> | 82.70                                      | 1.064**             | 4.880**             |
| 4                         | Line No. 4  | 28.89                | 2.495**              | 4.471**             | 8.12                | 2.158 <sup>NS</sup> | 0.069 <sup>NS</sup> | 98.02                                      | 1.281**             | 2.233**             |
| 5                         | Line No. 5  | 23.50                | 1.274**              | 1.383**             | 7.01                | 0.744 <sup>NS</sup> | 0.018 <sup>NS</sup> | 72.23                                      | 0.971**             | 22.23**             |
| 6                         | Line No. 6  | 21.89                | -0.080 <sup>NS</sup> | 4.341**             | 6.43                | 0.953 <sup>NS</sup> | 0.005 <sup>NS</sup> | 65.80                                      | 0.867**             | 3.039**             |
| 7                         | Line No. 7  | 23.78                | 0.015 <sup>NS</sup>  | 2.765**             | 6.44                | 2.137 <sup>NS</sup> | 0.02 <sup>NS</sup>  | 71.21                                      | 0.969**             | 4.319**             |
| 8                         | Line No. 8  | 25.28                | 2.056**              | 3.527**             | 6.90                | 0.936 <sup>NS</sup> | 0.008 <sup>NS</sup> | 61.36                                      | 0.815 <sup>NS</sup> | 0.223 <sup>NS</sup> |
| 9                         | Line No. 9  | 23.11                | 0.892**              | 0.587*              | 6.61                | 1.025 <sup>NS</sup> | 0.010 <sup>NS</sup> | 63.71                                      | 0.918**             | 0.495 <sup>NS</sup> |
| 10                        | Line No. 10 | 25.11                | 1.138**              | 1.296**             | 6.11                | 0.543 <sup>NS</sup> | 0.043 <sup>NS</sup> | 57.97                                      | 0.781**             | 0.126 <sup>NS</sup> |
| 11                        | Sweet-1     | 15.67                | 0.137 <sup>NS</sup>  | 0.507 <sup>NS</sup> | 7.43                | 0.419*              | 0.011 <sup>NS</sup> | 56.32                                      | 0.749**             | 0.612*              |
| 12                        | Super-1     | 24.44                | 0.374 <sup>NS</sup>  | 3.371**             | 8.51                | 0.236 <sup>NS</sup> | 0.034 <sup>NS</sup> | 82.70                                      | 1.110**             | 0.938**             |
| <b>Mean</b>               |             | <b>24.46</b>         | --                   | --                  | <b>7.27</b>         | --                  | --                  | <b>74.86</b>                               | --                  | --                  |
| <b>LSD<sub>0.05</sub></b> |             | <b>1.87</b>          | --                   | --                  | <b>0.39</b>         | --                  | --                  | <b>2.34</b>                                | --                  | --                  |





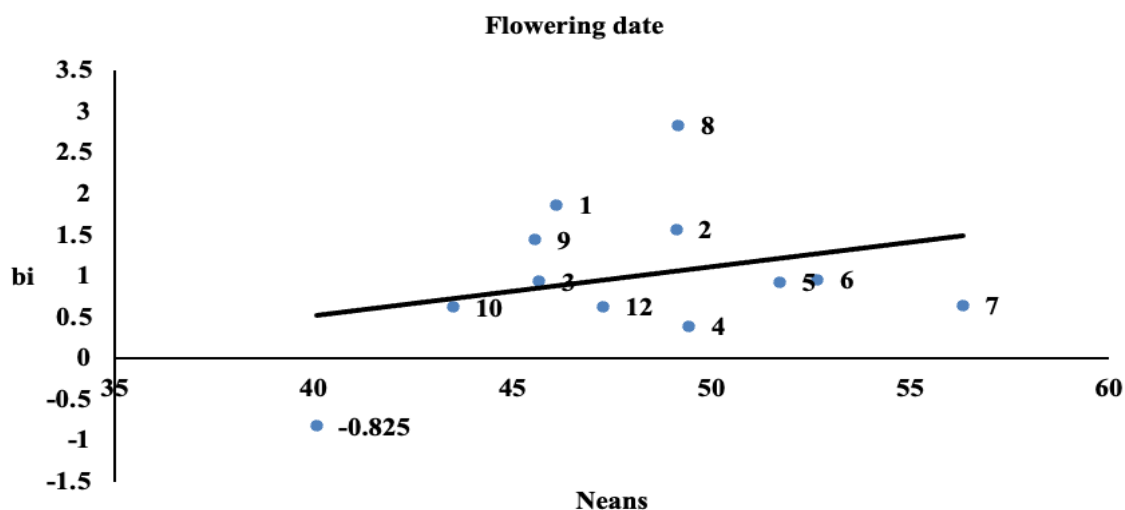
**Table (9). Estimates of stability for fresh seeds weight (g plant<sup>-1</sup>) and fresh pods weight (ton fed.<sup>-1</sup>) of 12 pea genotypes grown under different environments.**

| No.                 | Genotypes   | Fresh seeds weight (g plant <sup>-1</sup> ) |                     |                     | Fresh pods weight (ton fed. <sup>-1</sup> ) |                     |                      |
|---------------------|-------------|---|---------------------|---------------------|---|---------------------|----------------------|
|                     |             | $\bar{X}$                                   | $b_i$               | $S^2d$              | $\bar{X}$                                   | $b_i$               | $S^2d$               |
| 1                   | Line No. 1  | 42.10                                       | 1.150**             | 2.258**             | 4.557                                       | 1.218 <sup>NS</sup> | 0.0405 <sup>NS</sup> |
| 2                   | Line No. 2  | 47.60                                       | 1.275 <sup>NS</sup> | 0.164 <sup>NS</sup> | 4.764                                       | 1.257 <sup>NS</sup> | 0.0078 <sup>NS</sup> |
| 3                   | Line No. 3  | 41.58                                       | 1.114**             | 0.934**             | 4.135                                       | 1.063 <sup>NS</sup> | 0.0122 <sup>NS</sup> |
| 4                   | Line No. 4  | 49.05                                       | 1.383**             | 10.52**             | 4.901                                       | 1.281 <sup>NS</sup> | 0.0056 <sup>NS</sup> |
| 5                   | Line No. 5  | 36.27                                       | 0.964**             | 3.047**             | 3.612                                       | 0.972 <sup>NS</sup> | 0.0553 <sup>NS</sup> |
| 6                   | Line No. 6  | 32.69                                       | 0.877 <sup>NS</sup> | 0.018 <sup>NS</sup> | 3.290                                       | 0.867 <sup>NS</sup> | 0.0075 <sup>NS</sup> |
| 7                   | Line No. 7  | 34.51                                       | 0.911**             | 0.765*              | 3.560                                       | 0.968 <sup>NS</sup> | 0.0108 <sup>NS</sup> |
| 8                   | Line No. 8  | 33.68                                       | 0.524**             | 0.685*              | 3.068                                       | 0.815 <sup>NS</sup> | 0.0006 <sup>NS</sup> |
| 9                   | Line No. 9  | 34.76                                       | 0.926 <sup>NS</sup> | 0.131 <sup>NS</sup> | 3.186                                       | 0.917 <sup>NS</sup> | 0.0012 <sup>NS</sup> |
| 10                  | Line No. 10 | 32.18                                       | 0.868**             | 0.011 <sup>NS</sup> | 2.899                                       | 0.781 <sup>NS</sup> | 0.0003 <sup>NS</sup> |
| 11                  | Sweet-1     | 29.39                                       | 0.804**             | 0.091 <sup>NS</sup> | 2.816                                       | 0.750 <sup>NS</sup> | 0.0015 <sup>NS</sup> |
| 12                  | Super-1     | 42.89                                       | 1.204**             | 0.716*              | 4.135                                       | 1.110 <sup>NS</sup> | 0.0024 <sup>NS</sup> |
| Mean                |             | <b>38.06</b>                                | --                  | --                  | <b>3.743</b>                                | --                  | --                   |
| LSD <sub>0.05</sub> |             | <b>2.52</b>                                 | --                  | --                  | <b>0.11</b>                                 | --                  | --                   |

The lines No. 1, No. 2, No. 3, and No. 4 produced high yield in a variety of habitats, shown a high regression coefficient ( $b_i > 1$ ), and displayed a non-significant deviation from regression ( $S^2d$ ), indicating a particular adaptation of these genotypes to beneficial or high yielding environments. It claimed that these lines were capable of providing a high yield in favorable conditions with fertile soil, enough water, and other inputs.

Again, it is clear from the stability investigation that there is a wide

variation among genotypes; some genotypes displayed broad adaptation, while others showed specific adaptation to either favorable or unfavorable environments. Once more, according to Finlay and Wilkinson (1963) and Eberhart and Russell (1966), genotypes with a "b" value less than 1.0 and higher  $S^2d$  than zero are said to be specifically adapted to poor or unfavorable environments, whereas genotypes with a high "b" value are specifically adapted to favourable or high-yielding environments.



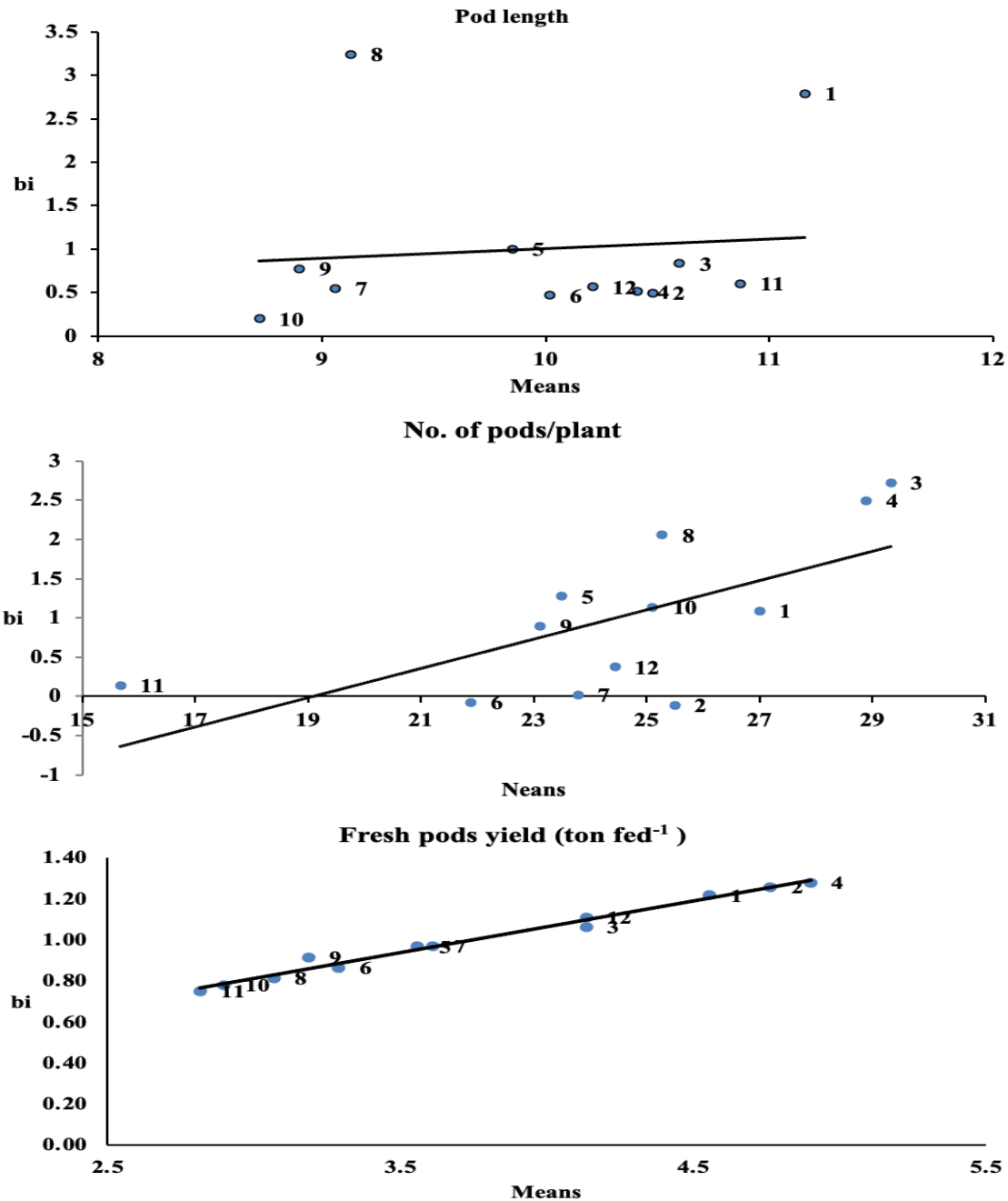


Fig. (3): Graphical illustration of the stability parameters (bi) and the mean performance (X) of individual genotypes for flowering date, pod length, number of pods/plant and fresh pods yield (ton fed<sup>-1</sup>).

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### دراسة الأقلمة والثبات المظهري لبعض التراكيب الوراثية الجديدة من البسلة

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أجريت هذه الدراسة تحت ستة بيئات مناخية مختلفة (ثلاث مناطق  $\times$  سنتين) تشمل محافظة سوهاج ومحافظة القليوبية ومحافظة الوادى الجديد خلال المواسم الشتوية لعامى ٢٠٢٢/٢٠٢١ و ٢٠٢٣/٢٠٢٢ فى تصميم القطاعات الكاملة العشوائية فى ثلاث مكررات لتقدير معايير الثبات الوراثي والمظهري لبعض السلالات المباشرة من البسلة مع بعض الأصناف المنتشرة فى الزراعة المصرية تحت هذه البيئات المناخية المختلفة.

أظهرت النتائج وجود إختلافات عالية المعنوية بين التراكيب الوراثية وبين البيئات وكذلك التفاعل بينهما لجميع الصفات تحت الدراسة. أظهرت قيم الثبات ( $S^2d$  و  $b_i$ ) بالنسبة لصفة محصول القرون الكلى بالطن للفدان أن التراكيب الوراثية تختلف فى قيمتها من حيث  $b_i$  كذلك تختلف فى قيمتها من حيث  $S^2d$  ويمكن ملاحظة أن معامل الإنحدار  $b_i$  للسلالات رقم ١ و ٢ و ٣ و ٤ كان غير معنوياً عن الواحد كما كانت قيمة الإنحراف عن الإنحدار  $S^2d$  غير معنوية عن الصفر وهذا يشير إلى أن هذه التراكيب تعتبر ثابتة بالنسبة لصفة المحصول وقد أحرزت أربعة من هذه السلالات (رقم ١ و ٢ و ٣ و ٤) محصول (٤.٥٥٧ ، ٤.٧٦٤ ، ٤.١٣٥ و ٤.٩١٠ طن للفدان على الترتيب) أعلى عن بقية السلالات مما يعتبرها سلالات مباشرة ويوصى بتسميتها أصنافاً قابلة للزراعة تحت ظروف مناطق الاختبار.