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# Genetic Variability, Heritability and Genetic Advance for Pod Yield and Its Related Traits in $F_3$ Populations of Spanish Bunch Groundnut (*Arachis hypogaea* L.)

**Jaimin K. Patel [a++*], G. K. Sapara [b#], R. S. Parmar [c†] and Riya [a++]**

*[a] Department of Genetics and Plant Breeding, Junagadh Agricultural University, Junagadh, India.*
*[b] Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh, India.*
*[c] College of Agriculture, Junagadh Agricultural University, Mota Bhandariya, Amreli, India.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The present investigation was carried out to estimate the genetic variability, heritability and genetic advance for pod yield and its related traits in $F_3$ generation of four different crosses of Spanish bunch groundnut (*Arachis hypogaea* L.) at Main Oilseeds Research Station, Junagadh Agricultural

[++] *Ph.D Scholar;*
[#] *Assistant Research Scientist;*
[†] *Assistant Professor;*
**Corresponding author: E-mail: jaiminpatel2792001@gmail.com;*

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University, Junagadh. The mean squares due to crosses were significant for all the characters suggesting presence of large amount of genetic variability in the material studied. The analysis of variance due to progenies within crosses were significant for most of the characters except oil content (%) in all four crosses. Wide range of variation was maximum for number of immature pods per plant, number of mature pods per plant, pod yield per plant, biological yield per plant, kernel yield per plant and 100-mature kernel weight in all four crosses. The PCV and GCV values were low to moderate for all four crosses except for number of immature pods per plant. High heritability coupled with high genetic advance as per cent of mean was registered for number of mature pods per plant, number of immature pods per plant, biological yield per plant and harvest index in AK-335 × ICGV-171024. High heritability coupled with high genetic advance as per cent of mean was registered for number of primary branches per plant, number of mature pods per plant, number of immature pods per plant, pod yield per plant, biological yield per plant and kernel yield per plant in GG-35 × ICGV-06141. High heritability coupled with high genetic advance as per cent of mean was registered for number of immature pods per plant, kernel yield per plant and 100-mature kernel weight in TPG-41 × TCGS-1694. High heritability coupled with high genetic advance as per cent of mean was registered for number of primary branches per plant, number of immature pods per plant, biological yield per plant and harvest index in ICGV-171013 × TG-90 indicating that additive gene effects governed these characters and could be chosen as selection criteria for formulating breeding strategies in groundnut.

*Keywords: Genetic variability genetic advance; groundnut breeding; genetic parameters.*

## 1. INTRODUCTION

Groundnut is one of the world's most important legume crop. It is commonly known as peanut, monkey-nut and goobernut (Gregory et al*.,* 1980). Groundnut is self-pollinated, allotetraploid with chromosome number 2n=40. *Arachis hypogaea* has two sub-species, *hypogaea*: Semi-spreading or spreading in habit, branching alternate, inflorescence simple and absent on main axis, seed dormancy usually present, foliage dark green and first branch on cotyledonary lateral always vegetative. It includes two varieties, Virginia bunch and Virginia runner and Peruvian runner, *fastigiata*: Erect and bunch in habit, branching sequential, inflorescence usually present on the main axis and first branching on the cotyledonary laterals are reproductive, seed dormancy usually absents and foliage light green. It includes two varieties Valencia and Spanish. The total area in India under groundnut cultivation is 49.50 lakh hectares in the year 2023-24 with production of 102.89 lakh tonnes and productivity of 2209 kg per hectare. In Gujarat, total area under groundnut cultivation is 16.94 lakh hectares with production of 46.42 lakh tonnes and productivity of 2739 kg per hectare in during year 2023-24. In plant breeding, assessment of genetic variability in the base population is the first step in any breeding programme. The variability parameters certainly determine the extent and quality of variability. Genetic diversity plays a pivotal role in survival and adaptability of a species. When a specific environment changes, slight genetic variation is necessary for it to adapt and survive. A species that has a large degree of genetic diversity among its population had more variation. Therefore, it is essential for a breeder to measure the variability with the help of parameters like phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic advance. By keeping eye on above mentioned phenomenon, present investigation was conducted to estimate the genetic variability, heritability and genetic advance for pod yield and its related traits in $F_3$ generation of four different crosses of Spanish bunch groundnut.

## 2. MATERIALS AND METHODS

The present field experiment on Spanish bunch groundnut was conducted in the Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh in Compact Family Block Design with two replications during summer, 2023. The experiment materials consist of four crosses *viz.,* AK-335 × ICGV-171024 (Cross I), GG-35 × ICGV-06141 (Cross II), TPG-41 × TCGS-1694 (Cross III) and ICGV-171013 × TG-90 (Cross IV) in $F_3$ generation. Observations were recorded from randomly selected 10 plants from each progeny in each replication for days to appearance of first flower, days to maturity, number of primary branches per plant, plant height, number of mature pods per plant, number of immature pods per plant, pod yield per plant, biological yield per plant, harvest index, kernel yield per plant, shelling out turn, 100-mature

kernel weight and oil content. The formula of Panse and Sukhatme (1995) was used to calculate variation for all the characters under study. The phenotypic and genotypic components of variances based on analysis of variance were estimated as per Burton (1952) approach. The heritability and genetic advance were estimated as per Allard (1960) approach.

## 3. RESULTS AND DISCUSSION

### 3.1 Analysis of Variance (ANOVA)

The analysis of variance between crosses for thirteen characters are presented in Table 1. A scrutiny of the results indicated that mean squares due to crosses were significant for all the characters. The analysis of variance between progenies within crosses for thirteen characters are presented in Tables 2, 3, 4 and 5. A scrutiny of the results also indicated that mean squares due to progenies within crosses were significant for most of the characters except oil content (%) in all four crosses. Bartlett's test "Chi-square test" used for the testing of homogeneity of error variance. If Chi-square test observed significant results, then it can be concluded that heterogeneity of error variance, so in case of significant result, the pooled analysis is not required. While if Chi-square test observed non-significant results, then it can be concluded that homogeneity of error variance, so in case of non-significant result, the pooled analysis is required or we need to go for pooled analysis. In the present study, the chi-square for Bartlett's test of homogeneity of error variances being significant for number of mature pods per plant, number of immature pods per plant, pod yield per plant, biological yield per plant, harvest index, kernel yield per plant and shelling out turn, while in case of days to appearance of first flower, days to maturity, number of primary branches per plant, plant height, 100-mature kernel weight and oil content found non-significant.

### 3.2 Genetic Variability Parameters

The range, general mean, coefficient of range, phenotypic and genotypic coefficient of variation, heritability (in broad sense), genetic advance and genetic advance expressed as per cent of mean values of the four crosses in $F_3$ generation are presented in Tables 6, 7, 8 and 9. All four crosses had almost equal mean for days to appearance of first flower (35.76 for Cross I, 35.51 for Cross II, 35.61 for Cross III and 34.01 for Cross IV), days to maturity (102.57 for Cross I, 104.58 for Cross II, 104.03 for Cross III and 102.24 for Cross IV), number or primary branches per plant (3.45 for Cross I, 3.65 for Cross II, 3.81 for Cross III and 3.56 for Cross IV), plant height (17.51 for Cross I, 17.28 for Cross II, 16.66 for Cross III and 16.30 for Cross IV). Number of mature pods per plant mean was higher in Cross IV (19.12) followed by Cross III (18.14), Cross I (12.98) and Cross II (12.09). Number of immature pods per plant mean was higher in Cross III (7.86) followed by Cross II (6.96), Cross I (4.57) and Cross IV (4.46). Pod yield per plant mean was higher in Cross IV (22.95) followed by Cross III (22.00), Cross II (18.40) and Cross I (15.49). Biological yield per plant was higher in Cross II (58.61) followed by Cross IV (52.88), Cross III (52.66) and Cross I (50.66). Harvest index was higher in Cross IV (43.78) followed by Cross III (42.07), Cross I (31.23) and Cross II (31.23). Kernel yield per plant was higher in Cross IV (15.51) followed by Cross III (15.03), Cross II (11.67) and Cross I (9.86). All four crosses had almost equal mean for shelling out turn (63.61% for Cross I, 63.58% for Cross II, 68.36% for Cross III and 67.56% for Cross IV). 100-mature kernel weight was higher in Cross IV (44.50) followed by Cross III (41.73), Cross I (38.28) and Cross II (38.20). All four crosses had almost equal mean of oil percentage (51.36% for Cross I, 53.89% for Cross II, 52.76% for Cross III and 50.62% for Cross IV).

The PCV and GCV values were lower for all four crosses for days to appearance of first flower (7.18 & 6.49 for Cross I, 5.81 & 4.25 for Cross II, 6.14 & 5.33 for Cross III and 5.67 & 4.78 for Cross IV). Vekariya et al*.* (2010) and Vasanthi et al*.* (2016) discovered comparable outcomes. Low PCV and GCV observed for days to maturity (7.18 & 6.49 for Cross I, 5.81 & 4.25 for Cross II, 6.14 & 5.33 for Cross III and 5.67 & 4.78 for Cross IV). Similar results were achieved by Padmaja et al*.* (2013). Moderate PCV and GCV for number of primary branches per plant was observed in Cross II (14.42 & 14.06) and in Cross IV (16.87 & 16.33), whereas in Cross I (8.89 & 7.79) and in Cross III (8.32 & 7.13) low PCV, GCV was observed. Low PCV and GCV for plant height (4.98 & 3.92 for Cross I, 5.32 & 4.31 for Cross II, 5.40 & 4.33 for Cross III and 5.83 & 4.88 for Cross IV). Similar results were achieved by Darvhankar et al*.* (2016). Moderate PCV and GCV for number of mature pods per plant (15.22 & 14.44 for Cross I, 14.20 & 13.99 for Cross II, 12.73 & 10.61 for Cross III and 12.86 & 10.03 for Cross IV). High PCV and GCV in Cross I (25.88 & 25.23), Cross III (21.61 & 21.18) and Cross IV (30.09 & 29.50), whereas in Cross II high PCV

(21.09) and moderate GCV (19.72) were observed for number of immature pods per plant. Moderate PCV and GCV in Cross II (12.88 & 11.25), Cross IV (14.64 & 10.12), low PCV and GCV in Cross I (9.03 & 7.66) while moderate PCV (13.22) and low GCV (8.70) in Cross III were observed for pod yield per plant. Moderate PCV and GCV for biological yield per plant (18.47 & 17.55 for Cross I, 18.13 & 15.75 for Cross II, 12.52 & 10.60 for Cross III and 12.79 & 11.87 for Cross IV). Moderate PCV and GCV in Cross I (11.66 & 10.67), Cross IV (14.06 & 13.07), low PCV and GCV in Cross II (6.46 & 4.22) while moderate PCV (11.56) and low GCV (9.41) in Cross III were observed for harvest index. Moderate PCV and GCV in Cross II (12.13 & 10.93), Cross III (13.62 & 12.46) and Cross IV (16.40 & 13.21), whereas in Cross I moderate PCV (10.71) and low GCV (9.77) were observed for kernel yield per plant. Low PCV and GCV for shelling out turn (3.70 & 2.76 for Cross I, 4.26 & 2.76 for Cross II, 5.75 & 3.86 for Cross III and 6.92 & 4.60 for Cross IV). Moderate PCV and GCV in Cross I (13.59 & 10.68), Cross III (15.75 & 13.82) and Cross IV (16.19 & 13.35), whereas in Cross II moderate PCV (10.08) and low GCV (7.58) were observed for 100-mature kernel weight. Low PCV and GCV for oil content (2.86 & 1.46 for Cross I, 2.56 & 1.34 for Cross II, 2.99 & 1.25 for Cross III and 3.25 & 1.74 for Cross IV).

High heritability were observed for number of immature pods per plant (95.01%) followed by biological yield per plant (90.31%), number of mature pods per plant (89.96%), harvest index (83.79%), kernel yield per plant (83.32%), days to appearance of first flower (81.70%), days to maturity (79.07%), number of primary branches per plant (76.73%) and pod yield per plant (71.99%) in Cross I, while in Cross II number of mature pods per plant (97.09%) followed by number of primary branches per plant (95.04%), number of immature pods per plant (87.42%), days to maturity (86.53%), kernel yield per plant (81.11%), pod yield per plant (76.37%) and biological yield per plant (75.51%). The results are in conformity with findings of Ragiri et al. (2023) and Darvhankar et al. (2016) for number of mature pods per plant and biological yield per plant, respectively. While in Cross III number of immature pods per plant (96.06%), kernel yield per plant (83.68%), 100-mature kernel weight (77.05%), days to appearance of first flower (75.38%), days to maturity (75.17%), number of primary branches per plant (73.43%) and biological yield per plant (71.63%) while in Cross IV number of immature pods per plant (96.17%) followed by number of primary branches per plant (93.62%), harvest index (86.37%), biological yield per plant (86.16%), days to appearance of first flower (70.95%) and plant height (70.11%). The similar result was also obtained for harvest index by Ramana et al. (2015).

Genetic advance expressed as percentage of mean was the highest for number of immature pods per plant (50.66%) followed by biological yield per plant (34.36%), number of mature pods per plant (28.20%) and harvest index (20.12%) in Cross I, in Cross II it was high in number of immature pods per plant (37.97%) followed by number of mature pods per plant (28.40%), number of primary branches per plant (28.23%), biological yield per plant (28.20%), kernel yield per plant (20.27) and pod yield per plant (20.26) while in Cross III it was high for number of immature pods per plant (42.76%) followed by 100-mature kernel weight (24.99%) and kernel yield per plant (23.49%) and in Cross IV it was high for number of immature pods per plant (59.60%) followed by number of primary branches per plant (32.54%), harvest index (25.02%), biological yield per plant (22.71%), 100-mature kernel weight (22.66%) and kernel yield per plant (21.93%). Other character showed moderate to low values. Low genetic advance was also observed for days to maturity by Dashora and Nagda (2002), for oil content by Suneetha et al. (2004) and John et al. (2013).

High heritability along with high genetic advance was observed in number of primary branches per plant, number of mature pods per plant, number of immature pods per plant, biological yield per plant and harvest index in Cross I and Cross IV. Thus, it can be concluded that this Cross I and Cross IV for number of primary branches per plant, number of mature pods per plant, number of immature pods per plant, biological yield per plant and harvest index were mainly under the influence of additive gene action and improvement in this traits would be possible through selection in the subsequent generations to isolate high yielding genotypes with desirable characteristics.

High heritability along with high genetic advance was observed in primary branches per plant, number of mature pods per plant, number of immature pods per plant, pod yield per plant, biological yield per plant and kernel yield per plant in Cross II. Hence, this represents the preponderance of additive gene action on the expression of these characters.

**Table 1. Analysis of variance (mean squares) between crosses for different thirteen characters in $F_3$ populations of four groundnut crosses**

| Source | df | Days to appearance of first flower | Days to maturity | Number of primary branches per plant | Plant Height (cm) | Number of mature pods per plant | Number of immature pods per plant | Pod yield per plant (g) |
|---|---|---|---|---|---|---|---|---|
| **Replications** | 1 | 23.88* | 72.16** | 1.76** | 9.79* | 33.63* | 2.19* | 135.02* |
| **Crosses** | 3 | 33.31* | 63.63** | 1.13** | 13.49* | 634.68** | 146.90** | 588.07** |
| **Error** | 3 | 2.15 | 1.71 | 0.03 | 0.80 | 1.50 | 0.14 | 6.02 |
| **Chi-square** | | NS | NS | NS | NS | S | S | S |

**Table 1. *Contd*….**

| Source | df | Biological yield per plant (g) | Harvest Index (%) | Kernel yield per plant (g) | Shelling out turn (%) | 100-mature kernel weight (g) | Oil content (%) |
|---|---|---|---|---|---|---|---|
| **Replications** | 1 | 2070.14** | 130.59 | 24.68* | 148.54* | 277.12** | 16.92* |
| **Crosses** | 3 | 583.83* | 2210.41** | 366.92** | 323.11* | 459.82** | 102.81** |
| **Error** | 3 | 23.38 | 25.73 | 1.16 | 12.08 | 3.66 | 0.66 |
| **Chi-square** | | S | S | S | S | NS | NS |

**,** Significant at p=0.05 and 0.01 levels, respectively.*

**Table 2. Analysis of variance (mean squares) between progenies within cross for different thirteen characters in $F_3$ populations of AK-335 × ICGV-171024**

| Source | df | Days to appearance of first flower | Days to maturity | Number of primary branches per plant | Plant Height (cm) | Number of mature pods per plant | Number of immature pods per plant | Pod yield per plant (g) |
|---|---|---|---|---|---|---|---|---|
| **Replications** | 1 | 10.09* | 12.61* | 0.57** | 0.99 | 6.94** | 0.07 | 6.02** |
| **Progenies** | 24 | 19.59** | 14.02** | 0.17** | 1.23** | 7.42** | 2.72** | 3.36** |
| **Error** | 24 | 1.97 | 1.64 | 0.02 | 0.29 | 0.39 | 0.07 | 0.55 |

**Table 2. *Contd*….**

| Source | df | Biological yield per plant (g) | Harvest Index (%) | Kernel yield per plant (g) | Shelling out turn (%) | 100-mature kernel weight (g) | Oil content (%) |
|---|---|---|---|---|---|---|---|
| **Replications** | 1 | 563.87** | 114.55** | 0.90* | 15.45* | 102.77** | 1.83 |
| **Progenies** | 24 | 166.60** | 24.36** | 2.04** | 8.62** | 43.77** | 2.73 |
| **Error** | 24 | 8.49 | 2.15 | 0.19 | 2.45 | 10.36 | 1.60 |

**,** Significant at p=0.05 and 0.01 levels, respectively.*

**Table 3. Analysis of variance (mean squares) between progenies within cross for different thirteen characters in $F_3$ populations of GG-35 × ICGV-06141**

| Source | df | Days to appearance of first flower | Days to maturity | Number of primary branches per plant | Plant Height (cm) | Number of mature pods per plant | Number of immature pods per plant | Pod yield per plant (g) |
|---|---|---|---|---|---|---|---|---|
| **Replications** | 1 | 16.83* | 11.45** | 0.15** | 8.33** | 1.66** | 1.35* | 41.25** |
| **Progenies** | 24 | 10.73** | 19.13** | 0.54** | 1.40** | 5.80** | 4.04** | 9.91** |
| **Error** | 24 | 3.24 | 1.38 | 0.01 | 0.29 | 0.09 | 0.27 | 1.33 |

**Table 3. *Contd*….**

| Source | df | Biological yield per plant (g) | Harvest Index (%) | Kernel yield per plant (g) | Shelling out turn (%) | 100-mature kernel weight (g) | Oil content (%) |
|---|---|---|---|---|---|---|---|
| **Replications** | 1 | 321.05** | 1.48 | 11.91** | 17.85 | 69.20** | 1.87 |
| **Progenies** | 24 | 198.07** | 5.99* | 3.63** | 10.40* | 23.19** | 2.42 |
| **Error** | 24 | 27.63 | 2.41 | 0.38 | 4.24 | 6.43 | 1.38 |

**,** Significant at p=0.05 and 0.01 levels, respectively.*

**Table 4. Analysis of variance (mean squares) between progenies within cross for different thirteen characters in $F_3$ populations of TPG-41 × TCGS-1694**

| Source | df | Days to appearance of first flower | Days to maturity | Number of primary branches per plant | Plant Height (cm) | Number of mature pods per plant | Number of immature pods per plant | Pod yield per plant (g) |
|---|---|---|---|---|---|---|---|---|
| **Replications** | 1 | 0.75 | 14.99* | 0.65** | 1.75* | 13.30** | 0.47 | 36.37* |
| **Progenies** | 24 | 13.75** | 15.02** | 0.17** | 1.33** | 9.04** | 5.65** | 12.12* |
| **Error** | 24 | 1.93 | 2.13 | 0.03 | 0.29 | 1.63 | 0.11 | 4.80 |

**Table 4. *Contd*….**

| Source | df | Biological yield per plant (g) | Harvest Index (%) | Kernel yield per plant (g) | Shelling out turn (%) | 100-mature kernel weight (g) | Oil content (%) |
|---|---|---|---|---|---|---|---|
| **Replications** | 1 | 411.36** | 31.16 | 8.22** | 24.52 | 32.25 | 7.00 |
| **Progenies** | 24 | 74.66** | 39.33** | 7.70** | 22.40* | 76.43** | 2.92 |
| **Error** | 24 | 12.34 | 7.99 | 0.68 | 8.48 | 9.91 | 2.06 |

**,** Significant at p=0.05 and 0.01 levels, respectively.*

**Table 5. Analysis of variance (mean squares) between progenies within cross for different thirteen characters in $F_3$ populations of ICGV-171013 × TG-90**

| Source | df | Days to appearance of first flower | Days to maturity | Number of primary branches per plant | Plant Height (cm) | Number of mature pods per plant | Number of immature pods per plant | Pod yield per plant (g) |
|---|---|---|---|---|---|---|---|---|
| **Replications** | 1 | 2.65 | 38.23** | 0.49** | 1.12 | 16.21* | 0.72** | 69.43** |
| **Progenies** | 24 | 10.66** | 16.82** | 0.70** | 1.55** | 9.73** | 3.53** | 16.68** |
| **Error** | 24 | 1.81 | 3.41 | 0.02 | 0.27 | 2.37 | 0.07 | 5.88 |

**Table 5. Contd….**

| Source | df | Biological yield per plant (g) | Harvest Index (%) | Kernel yield per plant (g) | Shelling out turn (%) | 100-mature kernel weight (g) | Oil content (%) |
|---|---|---|---|---|---|---|---|
| **Replications** | 1 | 844.02** | 60.60** | 7.14 | 126.96** | 83.89* | 8.20 |
| **Progenies** | 24 | 85.18** | 70.64** | 10.66** | 31.54* | 87.20** | 3.50 |
| **Error** | 24 | 6.33 | 5.17 | 2.27 | 12.20 | 16.65 | 1.94 |

**,** Significant at p=0.05 and 0.01 levels, respectively.*

**Table 6. Range, general mean, coefficient of range, phenotypic and genotypic coefficient of variation, heritability ($h^2_{(bs)}$), genetic advance and genetic advance expressed as per cent of mean for 13 characters in AK-335 × ICGV-171024 of Spanish bunch groundnut (summer)**

| Sr. No. | Characters | Range | General Mean | Coefficient of Range | PCV (%) | GCV (%) | $h^2_{(b.s.)}$ (%) | GA | GA as (%) of mean |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **Days to appearance of first flower** | 31.05-42.14 | 35.76 | 15.15 | 7.18 | 6.49 | 81.70 | 5.53 | 12.08 |
| **2** | **Days to maturity** | 97.60-107.14 | 102.57 | 4.66 | 2.73 | 2.43 | 79.07 | 4.56 | 4.44 |
| **3** | **No. of primary branches per plant** | 2.85-3.91 | 3.45 | 15.67 | 8.89 | 7.79 | 76.73 | 0.49 | 14.06 |
| **4** | **Plant Height (cm)** | 16.05-19.05 | 17.51 | 8.56 | 4.98 | 3.92 | 61.98 | 1.11 | 6.35 |
| **5** | **No. of mature pods per plant** | 8.86-17.09 | 12.98 | 31.70 | 15.22 | 14.44 | 89.96 | 3.66 | 28.20 |
| **6** | **No. of immature pods per plant** | 2.17-7.44 | 4.57 | 54.83 | 25.88 | 25.23 | 95.01 | 2.31 | 50.66 |
| **7** | **Pod yield per plant (g)** | 12.64-19.69 | 15.49 | 21.82 | 9.03 | 7.66 | 71.99 | 2.07 | 13.39 |
| **8** | **Biological yield per plant (g)** | 37.29-78.95 | 50.66 | 35.84 | 18.47 | 17.55 | 90.31 | 17.41 | 34.36 |
| **9** | **Harvest Index (%)** | 24.94-39.78 | 31.23 | 22.92 | 11.66 | 10.67 | 83.79 | 6.28 | 20.12 |
| **10** | **Kernel yield per plant (g)** | 7.54-12.73 | 9.86 | 25.59 | 10.71 | 9.77 | 83.32 | 1.81 | 18.38 |
| **11** | **Shelling out turn (%)** | 59.49-66.72 | 63.61 | 5.73 | 3.70 | 2.76 | 55.71 | 2.70 | 4.25 |
| **12** | **100-mature kernel weight (g)** | 28.06-47.38 | 38.28 | 25.62 | 13.59 | 10.68 | 61.73 | 6.62 | 17.28 |
| **13** | **Oil content (%)** | 48.19-53.71 | 51.36 | 5.42 | 2.86 | 1.46 | 26.15 | 0.79 | 1.54 |

**Table 7. Range, general mean, coefficient of range, phenotypic and genotypic coefficient of variation, heritability ($h^2_{(bs)}$), genetic advance and genetic advance expressed as per cent of mean for 13 characters in GG-35 × ICGV-06141 of Spanish bunch groundnut (summer)**

| Sr. No. | Characters | Range | General Mean | Coefficient of Range | PCV (%) | GCV (%) | $h^2_{(b.s.)}$ (%) | GA | GA as (%) of mean |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **Days to appearance of first flower** | 31.55-40.60 | 35.51 | 12.54 | 5.81 | 4.25 | 53.57 | 2.92 | 6.41 |
| **2** | **Days to maturity** | 99.13-114.96 | 104.58 | 7.40 | 3.06 | 2.85 | 86.53 | 5.71 | 5.46 |
| **3** | **No. of primary branches per plant** | 2.84-5.00 | 3.65 | 27.61 | 14.42 | 14.06 | 95.04 | 1.03 | 28.23 |
| **4** | **Plant Height (cm)** | 15.53-18.20 | 17.28 | 7.90 | 5.32 | 4.31 | 65.44 | 1.24 | 7.18 |
| **5** | **No. of mature pods per plant** | 5.83-13.94 | 12.09 | 41.06 | 14.20 | 13.99 | 97.09 | 3.43 | 28.40 |
| **6** | **No. of immature pods per plant** | 4.82-10.64 | 6.96 | 37.69 | 21.09 | 19.72 | 87.42 | 2.64 | 37.97 |
| **7** | **Pod yield per plant (g)** | 13.50-21.64 | 18.40 | 23.17 | 12.88 | 11.25 | 76.37 | 3.73 | 20.26 |
| **8** | **Biological yield per plant (g)** | 37.89-74.66 | 58.61 | 32.67 | 18.13 | 15.75 | 75.51 | 16.53 | 28.20 |
| **9** | **Harvest Index (%)** | 28.92-35.61 | 31.73 | 10.37 | 6.46 | 4.22 | 42.70 | 1.80 | 5.68 |
| **10** | **Kernel yield per plant (g)** | 9.05-13.66 | 11.67 | 20.30 | 12.13 | 10.93 | 81.11 | 2.37 | 20.27 |
| **11** | **Shelling out turn (%)** | 60.92-68.30 | 63.58 | 5.71 | 4.26 | 2.76 | 42.03 | 2.34 | 3.68 |
| **12** | **100-mature kernel weight (g)** | 30.74-43.53 | 38.20 | 17.21 | 10.08 | 7.58 | 56.57 | 4.48 | 11.74 |
| **13** | **Oil content (%)** | 51.30-55.32 | 53.89 | 3.77 | 2.56 | 1.34 | 27.31 | 0.78 | 1.44 |

**Table 8. Range, general mean, coefficient of range, phenotypic and genotypic coefficient of variation, heritability ($h^2_{(bs)}$), genetic advance and genetic advance expressed as per cent of mean for 13 characters in TPG-41 × TCGS-1694 of Spanish bunch groundnut (summer)**

| Sr. No. | Characters | Range | General Mean | Coefficient of Range | PCV (%) | GCV (%) | $h^2_{(b.s.)}$ (%) | GA | GA as (%) of mean |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **Days to appearance of first flower** | 31.50-43.13 | 35.61 | 15.58 | 6.14 | 5.33 | 75.38 | 4.35 | 9.53 |
| **2** | **Days to maturity** | 99.90-110.09 | 104.03 | 4.85 | 2.81 | 2.44 | 75.17 | 4.53 | 4.36 |
| **3** | **No. of primary branches per plant** | 3.12-4.25 | 3.81 | 15.40 | 8.32 | 7.13 | 73.43 | 0.48 | 12.59 |
| **4** | **Plant Height (cm)** | 14.03-17.17 | 16.66 | 10.04 | 5.40 | 4.33 | 64.16 | 1.19 | 7.14 |
| **5** | **No. of mature pods per plant** | 13.75-24.80 | 18.14 | 28.66 | 12.73 | 10.61 | 69.41 | 3.30 | 18.21 |
| **6** | **No. of immature pods per plant** | 4.98-13.21 | 7.86 | 45.26 | 21.61 | 21.18 | 96.06 | 3.36 | 42.76 |
| **7** | **Pod yield per plant (g)** | 18.16-29.49 | 22.00 | 23.77 | 13.22 | 8.70 | 43.28 | 2.59 | 11.79 |
| **8** | **Biological yield per plant (g)** | 39.76-64.41 | 52.66 | 23.67 | 12.52 | 10.60 | 71.63 | 9.73 | 18.48 |
| **9** | **Harvest Index (%)** | 37.28-53.74 | 42.07 | 18.09 | 11.56 | 9.41 | 66.24 | 6.64 | 15.78 |
| **10** | **Kernel yield per plant (g)** | 11.16-18.99 | 15.03 | 25.98 | 13.62 | 12.46 | 83.68 | 3.53 | 23.49 |
| **11** | **Shelling out turn (%)** | 61.51-75.00 | 68.36 | 9.88 | 5.75 | 3.86 | 45.07 | 3.65 | 5.34 |
| **12** | **100-mature kernel weight (g)** | 31.17-53.32 | 41.73 | 26.23 | 15.75 | 13.82 | 77.05 | 10.43 | 24.99 |
| **13** | **Oil content (%)** | 50.33-54.73 | 52.76 | 4.19 | 2.99 | 1.25 | 17.37 | 0.56 | 1.07 |

**Table 9. Range, general mean, coefficient of range, phenotypic and genotypic coefficient of variation, heritability ($h^2_{(bs)}$), genetic advance and genetic advance expressed as per cent of mean for 13 characters in ICGV-171013 × TG-90 of Spanish bunch groundnut (summer)**

| Sr. No. | Characters | Range | General Mean | Coefficient of Range | PCV (%) | GCV (%) | $h^2_{(b.s.)}$ (%) | GA | GA as (%) of mean |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **Days to appearance of first flower** | 29.57-38.85 | 34.01 | 13.56 | 5.67 | 4.78 | 70.95 | 3.65 | 8.29 |
| **2** | **Days to maturity** | 97.64-114.23 | 102.24 | 7.83 | 3.11 | 2.53 | 66.24 | 4.34 | 4.25 |
| **3** | **No. of primary branches per plant** | 2.96-5.06 | 3.56 | 26.22 | 16.87 | 16.33 | 93.62 | 1.16 | 32.54 |
| **4** | **Plant Height (cm)** | 14.58-18.00 | 16.39 | 10.50 | 5.83 | 4.88 | 70.11 | 1.38 | 8.42 |
| **5** | **No. of mature pods per plant** | 15.18-24.13 | 19.12 | 22.77 | 12.86 | 10.03 | 60.85 | 3.08 | 16.12 |
| **6** | **No. of immature pods per plant** | 2.11-6.60 | 4.46 | 51.49 | 30.09 | 29.50 | 96.17 | 2.66 | 59.60 |
| **7** | **Pod yield per plant (g)** | 18.92-33.22 | 22.95 | 27.42 | 14.64 | 10.12 | 47.85 | 3.31 | 14.43 |
| **8** | **Biological yield per plant (g)** | 43.84-69.22 | 52.88 | 22.46 | 12.79 | 11.87 | 86.16 | 12.01 | 22.71 |
| **9** | **Harvest Index (%)** | 37.57-66.82 | 43.78 | 28.02 | 14.06 | 13.07 | 86.37 | 10.95 | 25.02 |
| **10** | **Kernel yield per plant (g)** | 11.39-20.73 | 15.51 | 29.07 | 16.40 | 13.21 | 64.91 | 3.40 | 21.93 |
| **11** | **Shelling out turn (%)** | 60.56-72.87 | 67.56 | 9.22 | 6.92 | 4.60 | 44.22 | 4.26 | 6.30 |
| **12** | **100-mature kernel weight (g)** | 33.45-59.08 | 44.50 | 27.70 | 16.19 | 13.35 | 67.94 | 10.09 | 22.66 |
| **13** | **Oil content (%)** | 48.87-53.65 | 50.69 | 4.67 | 3.25 | 1.74 | 28.75 | 0.98 | 1.93 |

## 4. CONCLUSION

High heritability along with high genetic advance was observed in number of immature pods per plant, kernel yield per plant and 100-mature kernel weight in Cross III. Hence, this represents the preponderance of additive gene action on the expression of these characters and improvement in this traits would be possible through selection in the subsequent generations to isolate high yielding genotypes with desirable characteristics.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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