**Identification of heterotic hybrids in PEARL MILLET [PENNISETUM GLAUCUM (L.) R. BR.]**

**FOR yield and YIELD contributing traits**

**Abstract**

A set of 39 pearl millet (*Pennisetum glaucum* (L.) R. Br.] ) hybrids along with two checks Winner 4080 and Winner 4090 were evaluated at Deesa, Gujarat during summer season of 2024 in Randomized Complete Block Design (RCBD) with two replications to check the variability among the hybrids through PCA and cluster analysis and to identify the best performing hybrids based on standard heterosis. Analysis of variance showed significant genetic variation for all studied traits except for days to 50% flowering and number of tillers. The first three principal components having eigen value greater than one was extracted from the mean of 7 characters and they explained 69.8% variance in pearl millet hybrids. A variance of 34.1%, 19.0% and 16.6% were extracted from first, second and third principal components, respectively. Ward’s method of hierarchical clustering based on seven quantitative traits grouped 41 hybrids into ten clusters with clear differentiation for different quantitative traits. Cluster 1, 5, 6 and 10 were grouped the high yielding hybrids, therefore, breeders can use these hybrid parents for their line development program as well as hybrid development program. The standard heterosis ranged from -48.5% to 96.6% for grain yield. The hybrids viz., PMGH-5, PMGH-24, PMGH-26, PMGH-29, PMGH-31 and PMGH-32 recorded the highest standard heterosis for grain yield kg ha-1. These hybrids also exhibited desirable heterosis for important yield attributes suggesting that the heterosis for grain yield (kg ha-1) was associated with heterosis for component characters. Thus, these hybrids can be commercially exploited through heterosis breeding programme after testing in multi-location trial to work out its stability and in diseases screening trial to find out its resistance capacity against major pearl millet diseases in order to achieve hybrids with higher grain yield.

**Key words:** Pearl millet, PCA, Diversity, Clusters, Heterosis.

**Introduction**

Pearl millet is a significant crop globally, particularly in arid and semi-arid regions. India is the largest producer of millets, accounting for 38.40% of global production, followed by Niger, China, Nigeria, and Mali. In last two decades the production and productivity of pearl millet is increasing while, area is decreasing, this might due to climate change. The total area, production and productivity of India during 2024-25 was 72.1 lakh ha, 108.6 lakh tonnes and 1507 kg ha-1 respectively. Whereas, the summer area, production and productivity was 3.74 lakh ha, 10.15 lakh tonnes and 2717 kg ha-1 (DA&FW, 3rd advance estimate 2024-25). For summer pearl millet production Gujarat contributes 94% share followed by Maharashtra 3.55% and Tamil Nadu 1.67%. Productivity over the seasons was 1507 kg ha-1 whereas, its 2717 kg ha-1 during summer season and Gujarat is the major shareholder for production and productivity during summer season 2024. Thus, by considering the current scenario present study was conducted to identify best hybrid combination suitable for summer ecology of pearl millet.

**Materials and methods**

An experiment consisting of forty one hybrids including 39 test hybrids and 2 commercial hybrid as checks (Winner 4080 and Winner 4090). The assessment protocol was implemented utilizing a Randomized Block Design (RBD) with two replications in the summer season of 2024 at Deesa, Gujarat (24° 15' 30.6108'' N and 72° 11' 26.4264'' E). Agronomic observations encompassed monitoring 7 characters, including days to 50% flowering, plant height (cm), number of tillers, panicle length (cm), panicle girth (cm), grain yield (kg ha-1) and green fodder yield (tons ha-1). The collected data underwent analysis of variance, with each characters data for hybrids being scrutinized for Deesa location. This analysis was conducted utilizing various statistical methodologies viz., Principal component analysis with GRAPES software, the objective of principal component analysis is to identify the minimum number of components, which can explain maximum variability out of the total variability and also to rank hybrids on the basis of PC scores. Cluster analysis performed using NCSS 2025, v25.0.2 statistical software, using the Wards method of hierarchical clustering technique (Ward, 1963) and the hybrids were grouped based on similarity matrix. The hybrid performance was assessed by comparing it with a standard control (Standard heterosis/SH) as proposed by Meredith and Bridge (1972). The prescribed agronomic techniques for promoting robust crop development were implemented.

**Results and discussion**

The analysis of variance for the experiment revealed a significant differences among 41 hybrids for all the characters except for days to 50% flowering and number of tillers (Table 1). Also, the descriptive statistics indicating the presence of wide range of high variability in hybrids studied (Table 2). Range of variation was highest for grain yield, green fodder yield, plant height, panicle length and days to 50% flowering. Based on coefficient of variation higher variability was observed for green fodder yield, grain yield, number of tillers, panicle length and plant height. Higher range, coefficients of variation and large differences in mean values for most of the characters revealed that sufficient diversity existed among the hybrids and their characters. The present findings were similar with previous reports in pearl millet (Anuradha et al., 2018; Sharma et al., 2018 and Mahendrakar et al., 2019).

In present investigation, the mean data of seven quantitative characters were subjected to principal component analysis that follows a data reductionist approach involving a linear combination of optimally-weighted observed variables and helps in identifying the plant characters that contribute most towards the total variation. The first three principal components having eigen value greater than one were extracted from the mean of 7 characters and they explained 69.8% variance in pearl millet hybrids (Table 3). The first principal component (PC1) was the most important and accounted 34.1 % of variation. The major contributors for variation observed in first principle component were plant height, grain yield and green fodder yield. The variations in PC2 were mainly due to days to 50% flowering, number of tillers and panicle girth. PC3 imparted 16.6% variance mainly through panicle length. Remaining 30.1% variance exhibited by PC4, PC5, PC6 and PC7 (Table 4). The results indicated the role of traits (specific to each PC) which contributed more towards genetic divergence in discriminating the hybrids of pearl millet. The present study was in agreement with the PCA traits analysis of Animasaun et al., (2017), Sangwan et al., (2019), Mithlesh et al., (2020) in pearl millet.

Hierarchical clustering based on seven quantitative characters data using Ward’s method resulted in grouping of 41hybrids of pearl millet into 10 clusters (Table 5 and Fig 1). This would imply that there is a substantial genetic diversity among the hybrids which will be contributed by the hybrid parentage. Cluster 9 was found the biggest cluster and smallest clusters were cluster 10, 2, 3 and 8. Among the clusters, cluster 10 was high yielding (5332.5 kg ha-1) followed by clusters 6 (5253.7 kg ha-1) and 1 (5220.0 kg ha-1). Cluster 10 was having only one hybrid PMGH-38 and highest yielder, this reveals that the parents of this hybrids were highly diverse than other hybrids. Clusters 1, 4, 5, 6 and 9 were having 6, 6, 5, 5 and 8 hybrids this reveals that these hybrids within cluster having common parental lines either female or male. So, for improving the grain yield of hybrid, the parents of these hybrids viz., PMGH-38 (Cluster 10), PMGH-34 (Cluster 2), PMGH-36 (Cluster 2), PMGH-15 (Cluster 3), PMGH-17 (Cluster 3), PMGH-39 (Cluster 8) and PMGH-8 (Cluster 8) can be recombined for line development and can be crossed between cluster hybrid parents to develop heterotic hybrids.

Genetic variability parameters were studied for different characters of pearl millet (Table 6). Result showed that the PCV values were more than GCV values. All the given characters which indicated positive effect of environment on the characters expression. Among all the characters higher GCV was observed for grain yield and green fodder yield as PCV were observed for number of tillers, grain yield and green fodder yield compared to all other characters indicating the existence of high degree of genetic variability for all the given characters. Moderate GCV recorded for panicle length and plant height and PCV recorded for plant height, panicle length and panicle girth. Low GCV were recorded for days to 50 per cent flowering, number of tillers and panicle girth and PCV were recorded for days to 50 percent flowering. High and significant variability for plant height was recorded by Sagar and Sagar (2002); Lakhasmana et al. (2003), Sharma et al. (2003), for each plant grain production by Bhorkhataria et al. (2005); for dry fodder production on each plant by Vidyadhar et al. (2007). The heritability in general was high for a character i.e. plant height, panicle length, grain yield and green fodder yield. Similar estimation of heritability for various traits have been reported by Kulkarni et al. (2000); Sharma (2002). Genetic advance recorded highest for plant height, panicle length, grain yield and green fodder yield.

Standard heterosis of 39 pearl millet hybrids were estimated over two commercial checks i.e Winner 4080 and Winner 4090 (Table 7). heterosis % ranged from -48.5% to 96.6%. Fourteen hybrids exhibited more than 10% standard heterosis over both the checks, whereas, PMGH-31 (96.6%) exhibited highest heterosis % over both commercial checks and PMGH-30 (-48.5%) exhibited lowest heteosis %. Twenty six hybrids were showed superiority over Winner 4080 and fourteen hybrids showed superiority (>10%) over both the checks. Among the hybrids, PMGH-31 (75%), PMGH-5 (56.4), PMGH-32 (52.8), PMGH-29 (48.5), PMGH-24 (46.5%), PMGH-26 (43.3) and PMGH-38 (43.2%) were performed well and the hybrids which showed heterosis for grain yield (kg ha-1) also showed heterosis for yield contributing characters (Table 7). So, these hybrids can be further tested over multi-locations and subsequently proposed for release.

**COMPETING INTERESTS DISCLAIMER:**

**Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.**

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**Table 1: Analysis of variance for yield and other quantitative characters in pearl millet**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Source of Variation** | **Df** | **DFF** | **PHT** | **NOT** | **PL** | **PG** | **GY** | **GFY** |
| **Replication** | 1 | 1.44 | 204.298 | 9.333 | 8.048 | 0.373 | 22181.25 | 184.527 |
| **Treatment** | 40 | 12.67 | 795.07\* | 1.78 | 35.49\* | 0.11\* | 2000587.23\* | 91.90\* |
| **Error** | 41 | 10.93 | 219.77 | 1.58 | 4.21 | 0.05 | 807262.68 | 36.06 |

**\*\*Significant at 1% level, \* Significant at 5% level.** DFF: Days to 50% flowering; PH: Plant height; NOT: Number of tillers; PL: Panicle length (cm); PG: Panicle girth (cm); GY: Grain yield (kg ha-1) and GFY: Green fodder yield (tons ha-1).

**Table 2: Descriptive statistics for yield and other quantitative characters in pearl millet**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Characters** | **Minimum** | **Maximum** | **Mean** | **Std. Deviation** | **Coefficient of Variation** |
| **DFF** | 46 | 59 | 51.98 | 2.5 | 0.050 |
| **PHT** | 165 | 266 | 204.56 | 19.71 | 0.100 |
| **NOT** | 3.5 | 7 | 4.77 | 0.94 | 0.200 |
| **PL** | 22 | 42 | 28.17 | 4.13 | 0.150 |
| **PG** | 2.8 | 3.7 | 3.24 | 0.23 | 0.070 |
| **GY** | 2190 | 6517.5 | 4198.86 | 986.32 | 0.230 |
| **GFY** | 14.3 | 50.8 | 23.08 | 6.78 | 0.290 |

DFF: Days to 50% flowering; PH: Plant height; NOT: Number of tillers; PL: Panicle length (cm); PG: Panicle girth (cm); GY: Grain yield (kg ha-1) and GFY: Green fodder yield (tons ha-1).

**Table 3: Eigen values in response to number of components for the estimated variables of pearl millet.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Principal components** | **eigen value** | **percentage of variance** | **cumulative percentage of variance** |
| PC1 | 2.39 | 34.14 | 34.14 |
| PC2 | 1.33 | 19.01 | 53.15 |
| PC3 | 1.16 | 16.64 | 69.80 |
| PC4 | 0.79 | 11.41 | 81.21 |
| PC5 | 0.70 | 10.04 | 91.26 |
| PC6 | 0.40 | 5.79 | 97.05 |
| PC7 | 0.20 | 2.94 | 100 |

**Table 4: Percent contribution of variables on principal components**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Variables** | **PC1** | **PC2** | **PC3** | **PC4** | **PC5** | **PC6** | **PC7** |
| DFF | 5.55 | 29.89 | 10.09 | 12.53 | 27.52 | 14.24 | 0.15 |
| PHT | 32.52 | 0.25 | 3.28 | 0.02 | 0.78 | 22.65 | 40.47 |
| NOT | 0.30 | 31.58 | 10.90 | 52.22 | 2.88 | 1.80 | 0.29 |
| PL | 0.32 | 1.74 | 60.69 | 13.12 | 21.32 | 0.71 | 2.08 |
| PG | 5.34 | 23.36 | 10.52 | 13.74 | 46.58 | 0.12 | 0.30 |
| GY | 22.16 | 10.21 | 4.18 | 7.99 | 0.53 | 52.49 | 2.41 |
| GFY | 33.79 | 2.94 | 0.31 | 0.34 | 0.36 | 7.96 | 54.27 |

DFF: Days to 50% flowering; PH: Plant height; NOT: Number of tillers; PL: Panicle length (cm); PG: Panicle girth (cm); GY: Grain yield (kg ha-1) and GFY: Green fodder yield (tons ha-1).

**Table 5: Cluster analysis of Pearl millet hybrids for grain yield**

|  |  |  |  |
| --- | --- | --- | --- |
| **Clusters** | **No. of hybrids** | **Hybrid\_Code** | **Mean grain yield**  **(t ha-1)** |
| 1 | 6 | PMGH-24, PMGH-27, PMGH-28, PMGH-31, PMGH-37, PMGH-4 | 5220.0 |
| 2 | 2 | PMGH-34, PMGH-36 | 4225.0 |
| 3 | 2 | PMGH-15, PMGH-17 | 3986.3 |
| 4 | 6 | PMGH-11, PMGH-13, PMGH-19, PMGH-20, PMGH-22, PMGH-6 | 3383.8 |
| 5 | 5 | PMGH-1, PMGH-2, PMGH-25, PMGH-29, PMGH-3 | 4679.0 |
| 6 | 5 | PMGH-23, PMGH-26, PMGH-32, PMGH-33, PMGH-5 | 5253.8 |
| 7 | 4 | PMGH-10, PMGH-21, PMGH-7, PMGH-9 | 4020.6 |
| 8 | 2 | PMGH-39, PMGH-8 | 3602.5 |
| 9 | 8 | PMGH-12, PMGH-14, PMGH-16, PMGH-18, PMGH-30, PMGH-35, Winner 4080, Winner 4090 | 3250.0 |
| 10 | 1 | PMGH-38 | 5332.5 |

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**Fig. 1. Dendrogram showing 41 pearl millet hybrids grouped using Ward Method.**

**Table 6: Estimates of range, genotypic and phenotypic coefficient of variation, genetic advance and heritability (broad sense per cent) of different traits of pearl millet hybrids.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Characters** | **Mean** | **Range** | **PCV (%)** | **GCV (%)** | **heritability** | **Genetic.adv (%) (i=5%)** |
| **Days to 50% flowering** | 52.0 | 46-59 | 6.65 | 1.81 | 0.074 | 1.01 |
| **Plant height** | 204.6 | 165-266 | 11.05 | 8.32 | 0.567 | 12.90 |
| **Number of tillers** | 4.8 | 3.5-7 | 27.25 | 6.54 | 0.058 | 3.23 |
| **Panicle length** | 28.2 | 22-42 | 16.02 | 14.22 | 0.788 | 25.99 |
| **Panicle girth** | 3.2 | 2.8-3.7 | 9.19 | 5.21 | 0.322 | 6.09 |
| **Grain yield** | 4198.9 | 2190-6517.5 | 28.39 | 18.51 | 0.425 | 24.86 |
| **Green fodder yield** | 23.1 | 14.3-50.8 | 34.68 | 22.91 | 0.436 | 31.18 |

**Table 7: Standerd heterosis of pearl millet hybrids over both the checks Winner 4080 and Winner 4090.**

| **Hybrid Code** | **DFF** | | **PHT** | | **NOT** | | **PL** | | **PG** | | **GY** | | **GFY** | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **% Heterosis over Winner 4080** | **% Heterosis over Winner 4090** | **% Heterosis over Winner 4080** | **% Heterosis over Winner 4090** | **% Heterosis over Winner 4080** | **% Heterosis over Winner 4090** | **% Heterosis over Winner 4080** | **% Heterosis over Winner 4090** | **% Heterosis over Winner 4080** | **% Heterosis over Winner 4090** | **% Heterosis over Winner 4080** | **% Heterosis over Winner 4090** | **% Heterosis over Winner 4080** | **% Heterosis over Winner 4090** |
| **PMGH-1** | 1 | -1 | 18.8 | 7 | -9.1 | 43 | 35.4 | 19 | 5.2 | 8 | 43.3 | 11.8 | 19.9 | 3 |
| **PMGH-2** | -2 | -4 | 20.5 | 9 | -36.4 | 0 | 33.3 | 18 | 9.5 | 12 | 42.0 | 10.8 | 6.3 | -9 |
| **PMGH-3** | 3 | 1 | 22.8 | 11 | -18.2 | 29 | 20.8 | 7 | 9.8 | 12 | 23.3 | -3.9 | 19.0 | 2 |
| **PMGH-4** | 1 | -1 | 15.4 | 4 | -18.2 | 29 | 25.0 | 10 | -0.2 | 2 | 36.0 | 6.1 | 13.4 | -3 |
| **PMGH-5** | 4 | 2 | 20.2 | 9 | -9.1 | 43 | 6.3 | -6 | 6.7 | 9 | 75.7 | 37.0 | 17.2 | 0 |
| **PMGH-6** | -1 | -3 | 6.7 | -4 | -18.2 | 29 | 33.3 | 18 | 8.9 | 11 | -11.7 | -31.1 | -13.8 | -26 |
| **PMGH-7** | 0 | -2 | 19.7 | 8 | 27.3 | 100 | 25.0 | 10 | 6.3 | 9 | 4.0 | -18.9 | 3.3 | -12 |
| **PMGH-8** | 0 | -2 | 13.2 | 2 | -18.2 | 29 | 35.4 | 19 | 4.0 | 6 | 33.4 | 4.1 | 16.5 | 0 |
| **PMGH-9** | -6 | -8 | 3.1 | -7 | 27.3 | 100 | 29.2 | 14 | 10.0 | 13 | 4.7 | -18.3 | -32.7 | -42 |
| **PMGH-10** | -3 | -5 | 12.9 | 2 | 18.2 | 86 | 18.8 | 5 | 16.4 | 19 | 43.1 | 11.6 | 33.8 | 14 |
| **PMGH-11** | -3 | -5 | -0.8 | -10 | -18.2 | 29 | 12.5 | -1 | 9.0 | 12 | 6.1 | -17.2 | 7.0 | -9 |
| **PMGH-12** | 9 | 7 | 0.6 | -9 | 0.0 | 57 | 6.3 | -6 | 2.3 | 5 | -20.0 | -37.6 | -32.7 | -42 |
| **PMGH-13** | -1 | -3 | 8.7 | -2 | 9.1 | 71 | 18.8 | 5 | 12.2 | 15 | 11.2 | -13.2 | -10.8 | -24 |
| **PMGH-14** | 8 | 6 | 6.7 | -4 | -27.3 | 14 | -4.2 | -15 | 16.3 | 19 | -18.3 | -36.3 | -18.8 | -31 |
| **PMGH-15** | 2 | 0 | 6.2 | -4 | 0.0 | 57 | -11.5 | -22 | -11.4 | -9 | 34.4 | 4.8 | 10.0 | -6 |
| **PMGH-16** | 7 | 5 | 10.4 | 0 | -36.4 | 0 | -6.3 | -17 | -3.0 | -1 | 12.6 | -12.2 | -15.1 | -27 |
| **PMGH-17** | -8 | -10 | -4.2 | -13 | 0.0 | 57 | -10.4 | -21 | -2.9 | -1 | 6.1 | -17.2 | -32.2 | -42 |
| **PMGH-18** | 5 | 3 | 9.8 | -1 | -9.1 | 43 | 8.3 | -4 | -2.5 | 0 | 2.8 | -19.8 | -30.9 | -41 |
| **PMGH-19** | -3 | -5 | -7.6 | -16 | -27.3 | 14 | 12.5 | -1 | 6.5 | 9 | -7.0 | -27.4 | -28.6 | -39 |
| **PMGH-20** | 4 | 2 | 8.7 | -2 | -18.2 | 29 | 39.6 | 23 | 6.1 | 8 | 8.4 | -15.5 | -2.1 | -16 |
| **PMGH-21** | -5 | -7 | 3.1 | -7 | 18.2 | 86 | 14.6 | 1 | 16.4 | 19 | 33.3 | 4.0 | -20.1 | -32 |
| **PMGH-22** | 3 | 1 | 14.9 | 4 | -9.1 | 43 | 12.5 | -1 | 11.1 | 14 | 5.4 | -17.8 | -13.8 | -26 |
| **PMGH-23** | 3 | 1 | 27.2 | 15 | -9.1 | 43 | 14.6 | 1 | 7.2 | 10 | 52.6 | 19.1 | 11.0 | -5 |
| **PMGH-24** | 4 | 2 | 17.1 | 6 | -9.1 | 43 | 14.6 | 1 | -0.2 | 2 | 64.6 | 28.4 | 28.2 | 10 |
| **PMGH-25** | -5 | -7 | 18.0 | 7 | -27.3 | 14 | 6.3 | -6 | 12.1 | 15 | 30.2 | 1.6 | 32.5 | 13 |
| **PMGH-26** | 0 | -2 | 27.2 | 15 | 0.0 | 57 | 4.2 | -8 | 1.9 | 4 | 61.0 | 25.6 | 20.4 | 3 |
| **PMGH-27** | 3 | 1 | 13.8 | 3 | -18.2 | 29 | 8.3 | -4 | 3.7 | 6 | 46.0 | 13.9 | 48.0 | 27 |
| **PMGH-28** | 4 | 2 | 13.2 | 2 | -18.2 | 29 | 18.8 | 5 | 1.4 | 4 | 48.6 | 15.9 | 13.6 | -3 |
| **PMGH-29** | 1 | -1 | 9.6 | -1 | -36.4 | 0 | 10.4 | -3 | 3.3 | 6 | 66.9 | 30.2 | -30.2 | -40 |
| **PMGH-30** | 8 | 6 | 10.4 | 0 | -36.4 | 0 | 6.3 | -6 | -2.2 | 0 | -33.9 | -48.5 | -22.2 | -34 |
| **PMGH-31** | 2 | 0 | 18.0 | 7 | -27.3 | 14 | 17.9 | 4 | 1.2 | 3 | 96.6 | 53.4 | 39.8 | 20 |
| **PMGH-32** | 7 | 5 | 27.0 | 15 | -9.1 | 43 | 14.6 | 1 | 19.3 | 22 | 71.7 | 33.9 | 60.3 | 37 |
| **PMGH-33** | 2 | 0 | 30.3 | 18 | -18.2 | 29 | 16.9 | 3 | 12.7 | 15 | 31.4 | 2.5 | 24.8 | 7 |
| **PMGH-34** | -3 | -5 | 19.4 | 8 | -36.4 | 0 | 39.6 | 23 | -2.5 | 0 | 38.5 | 8.1 | 20.1 | 3 |
| **PMGH-35** | 3 | 1 | 22.8 | 11 | -27.3 | 14 | -8.3 | -19 | 7.6 | 10 | 12.9 | -11.9 | 9.6 | -6 |
| **PMGH-36** | 6 | 4 | 40.4 | 27 | -18.2 | 29 | 54.2 | 36 | -8.9 | -7 | 16.4 | -9.2 | 23.6 | 6 |
| **PMGH-37** | 1 | -1 | 21.3 | 10 | -27.3 | 14 | 2.1 | -10 | -9.8 | -8 | 52.9 | 19.3 | 42.1 | 22 |
| **PMGH-38** | 9 | 7 | 49.4 | 35 | 9.1 | 71 | 4.2 | -8 | -10.7 | -9 | 60.9 | 25.5 | 140.4 | 106 |
| **PMGH-39** | 1 | -1 | 13.2 | 2 | -9.1 | 43 | 75.0 | 54 | -2.2 | 0 | -16.1 | -34.6 | -13.4 | -26 |
| **Winner 4080** | 0 | -2 | 0.0 | -10 | 0.0 | 57 | 0.0 | -12 | 0.0 | 2 | 0.0 | -22.0 | 0.0 | -14 |
| **Winner 4090** | 2 | 0 | 10.7 | 0 | -36.4 | 0 | 13.3 | 0 | -2.2 | 0 | 28.2 | 0.0 | 16.9 | 0 |

PMGH: Pearl millet grain hybrid; DFF: Days to 50% flowering; PH: Plant height; NOT: Number of tillers; PL: Panicle length (cm); PG: Panicle girth (cm); GY: Grain yield (kg ha-1) and GFY: Green fodder yield (tons ha-1)

**Table 1: Analysis of variance for yield and other quantitative characters in pearl millet**