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**Research Note**

# Assessment of combining ability for yield and micronutrients in pearl millet

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**Abstract**
Present experiment was conducted with five male sterile lines (female parents) and nine testers (male parents) of pearl millet in line x tester fashion. Both GCA and SCA variances were highly significant for all characters. The predictability ratio of GCA and SCA revealed preponderance of non-additive genetic variance for all the characters. The parents like J-2340, J-2555 and J-2552 were identified as good general combiners for grain yield per plant and some other components. Majority of their crosses had also displayed significant and desirable *sca* effects, coupled with high *per se* performance for grain yield per plant. The hybrids *viz.,* JMSA$_1$ 20141 x 81-SB-14, ICMA$_4$ 10444 x J-2555 and JMSA$_5$ 20142 x 150-SB-14 were recorded the significant *sca* effect in desirable direction for grain yield and some other important characters. Thus, these hybrids can be commercially exploited through heterosis breeding programme after testing in multi-locational trial to work out its stability and diseases screening trials to find out its resistance capacity against major pearl millet diseases in order to achieve hybrids with high grain yield in pearl millet.

**Keywords**
Combining ability, *Pennisetum glaucum*, grain yield, line x tester

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is a staple diet for the vast majority of poor farmers and also form an important fodder crop for livestock population in arid and semi-arid regions of India. Efforts to develop pearl millet inbreds have greatly increased since the discovery of cytoplasmic-nuclear male sterility (Burton, 1958) and the development of single cross forage and grain hybrids. With the production and extensive testing of single crosses with Tift 23A$_{1,}$ Indian breeders were able to announce the release of 'HB-1' first pearl millet hybrid in 1965 (Athwal, 1965). It is well known fact that high yielding parent or line may or may not combine well, when used in hybridization. Under such circumstances, studies on general combining ability and specific combining ability effects for quantitative traits are important. Combining ability studies regarded useful to select best combining parents, which upon crossing would produce more desirable segregates. Such studies also elucidate the nature and magnitude of gene actions involved in the inheritance of grain yield and its components, which will decide the breeding programme to be followed in segregating generations. Good combining ability of improved inbreds is essential because inbreds are usually used to produce hybrids and synthetics. Both GCA and SCA are important, depending on the use of the inbred and traits of interest (Kumar *et al.,* 1982; Gartan *et al.,* 1988).

Five male sterile lines *viz.*, ICMA$_1$ 98222, ICMA$_1$ 09555, ICMA$_4$ 10444, JMSA$_1$ 20141 and JMSA$_5$ 20142 were crossed with nine diverse restorer lines *viz.,* 149-SB-14, 150-SB-14, 158-SB-14, J-2340, J-2540, J-2552, J-2555, 81-SB-14 and 85-SB-14 in a line x tester mating design during summer 2014. The resultant 45 cross combinations along with fertile counter parts of five male sterile lines, nine pollinators and the standard check, GHB 558 were grown in a randomized block design with three replications during *Kharif* 2014 at Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar (Gujarat), India. Each entry was represented by a single row of 5.0 m length spaced at 60 x 15 cm. Recommended agronomic practices and plant protection measures were adopted to raise healthy crop. Observations were recorded on five randomly selected plants for each entry, in each replication for various characters. The combining ability analysis is carried out using line x tester mating design as per the procedure suggested by Kempthorne (1957).

The analysis of variance for combining ability (Table 1) showed that general combining ability and specific combining ability variances were highly significant for all the characters. The results suggested the importance of both additive and non additive genetic components in the inheritance of all the characters. However, GCA:SCA variance ratio indicated the predominance of non-additive genetic variance for plant height, ear head girth, ear head weight, test weight, grain yield per plant, harvest index, Fe content and Zn content. Similar results were reported for one character or more than one characters by Parmar *et al.* (2013), Bhadalia *et*

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*al.* (2014), Singh and Sharma (2014) and Mungra *et al.* (2015).

A perusal of the general combining ability effects for parents (Table 2) revealed that none of the parents was good general combiners for all the characters, but good combining ability for multiple characters could be noticed in some parents. Out of fourteen parents, J-2340 has good general combining ability for grain yield per plant. J-2555 was found to be good source of genes for plant height, ear head girth, test weight, Fe and Zn content. Whereas, 150-SB-14 recorded significant *gca* effects in desired direction for plant height, ear head weight, test weight and Fe content. The 150-SB-14 was a good general combiner for ear head girth, test weight and Fe content. These good combiner parents may be used in crop breeding programme aimed at improvement of the respective characters. Further, consideration of *per se* performance in combination with combining ability estimates was reported to provide a better criteria for the choice of superior parents in hybridization programmes (Rao, 1972). Majority of the crosses of these parents had also registered significant and positive *sca* effects for grain yield per plant. Hence, these parents can be helpful in further pearl millet breeding programme to improve yield potentiality.

It is apparent that none of the cross combination was found to have consistently significant *sca* effects in desired direction for all the characters. Among 45 crosses, 08 hybrids exhibited significant and positive *sca* effects for grain yield per plant (Table 3). These crosses also displayed significant and desirable *sca* effects for yield components. The best specific combination was observed in cross $JMSA_1$ 20141 x 81-SB-14 for grain yield per plant and involved average x average combining parents. This cross was also expressed good specific combining ability for ear head girth, ear head weight, Zn content, test weight and harvest index. The cross combinations *viz.*, $ICMA_4$ 10444 x J-2555 and $JMSA_5$ 20142 x 150-SB-14 also showed high, significant and positive *sca* effects for grain yield per plant and some other yield attributing characters. This indicated that the high *sca* effect observed for grain yield per plant was associated with desirable *sca* effect manifested by its component characters *viz.*, plant height, ear head girth, ear head weight per plant and test weight.

The good general combiners when crossed may not always produce the best hybrid. Marked negative effects in crosses between good x good were noteworthy, which could be attributed to the lack of complementation between favourable alleles of the parents involved. Marked positive *sca* effects in crosses between good x poor and poor x poor could be ascribed to better complementation between favourable alleles of parents involved. These findings are in agreement with the earlier findings of Lakshmana *et al.* (2011) and Parmar *et al.* (2013).

In the present study, hybrid, $JMSA_1$ 20141 x 81-SB-14 expressed significant *sca* effect for grain yield per plant, ear head girth, ear head weight, Zn content, test weight and harvest index. Another hybrid, $ICMA_4$ 10444 x J-2555 showed significant *sca* effect in desirable direction for grain yield per plant, plant height, ear head girth, ear head weight, Fe content and harvest index. Hybrid, $JMSA_5$ 20142 x 150-SB-14 recorded significant *sca* effect in desirable direction for grain yield per plant and harvest index. Thus, these hybrids can be commercially exploited through heterosis breeding programme after testing in multi-locational trial to work out its stability and resistance capacity against major pearl millet diseases in order to achieve hybrids with high grain yield in pearl millet.

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**Table 1. Analysis of variance for combining ability and variance components for different characters in pearl millet**

| Source | d.f. | Grain yield per plant | Harvest index | Fe content | Zn content |
|---|---|---|---|---|---|
| **Replications** | 2 | 57.652 | 23.523 | 0.689 | 125.607 |
| **Lines** | 4 | 395.285 | 39.173 | 920.733**++ | 35.352 |
| **Testers** | 8 | 599.557+ | 104.779 | 344.050*+ | 117.846+ |
| **Lines x Testers** | 32 | 290.960** | 59.285** | 135.758** | 56.173** |
| **Error** | 88 | 38.917 | 17.513 | 4.212 | 13.153 |
| **Variance components** | | | | | |
| $\sigma^2$**l** | | 13.199 | 0.802 | 33.945** | 0.822 |
| $\sigma^2$**t** | | 37.376 | 5.818 | 22.656* | 6.980 |
| $\sigma^2$**lt** | | 84.014** | 13.924** | 43.849** | 14.340** |
| $\sigma^2$**GCA** | | 21.833** | 2.593* | 29.913** | 3.021* |
| $\sigma^2$**SCA** | | 84.014** | 13.924** | 43.849** | 14.340** |
| $\sigma^2$**GCA/**$\sigma^2$**SCA** | | 0.2600 | 0.186 | 0.682 | 0.211 |

| Source | d.f. | Plant height | Ear head weight | Ear head girth | Test Weight |
|---|---|---|---|---|---|
| **Replications** | 2 | 19.091 | 15.652 | 0.043 | 0.829 |
| **Lines** | 4 | 1407.269*++ | 399.870 | 0.661+ | 4.111 |
| **Testers** | 8 | 2968.581**++ | 670.902 | 0.604+ | 11.450*+ |
| **Lines x Testers** | 32 | 388.625** | 343.754** | 0.308** | 4.791** |
| **Error** | 88 | 16.120 | 21.008 | 0.017 | 0.056 |
| **Variance components** | | | | | |
| $\sigma^2$**l** | | 51.524* | 14.032 | 0.024 | 0.150 |
| $\sigma^2$**t** | | 196.831** | 43.326 | 0.039 | 0.760* |
| $\sigma^2$**lt** | | 124.169** | 107.582** | 0.097** | 1.578** |
| $\sigma^2$**GCA** | | 85.681** | 24.494** | 0.029** | 0.368** |
| $\sigma^2$**SCA** | | 124.169** | 107.582** | 0.097** | 1.578** |
| $\sigma^2$**GCA/**$\sigma^2$**SCA** | | 0.690 | 0.228 | 0.303 | 0.233 |

*, ** Significant at 5% and 1% levels against error respectively and +, ++ Significant at 5% and 1% levels against line x tester respectively

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**Table 2. General combining ability effect of parents for different characters in pearl millet**

| Sr. No. | Parents | Plant height | Ear head weight | Ear head girth | Test weight | Grain yield / plant | Harvest Index | Fe content | Zn content |
|---|---|---|---|---|---|---|---|---|---|
| **Lines** | | | | | | | | | |
| 1 | $ICMB_1$ 98222 | -8.24** | -5.48* | 0.14 | -0.41** | -4.97 | -1.18 | 6.46** | 1.78 |
| 2 | $ICMB_1$ 09555 | -0.02 | 1.37 | -0.23** | 0.17 | 0.84 | 0.09 | -5.36** | 0.00 |
| 3 | $ICMB_4$ 10444 | -4.76* | 3.63 | 0.12 | -0.15 | 3.73 | 1.10 | 6.20** | -0.74 |
| 4 | $JMSB_1$ 20141 | 10.59** | 2.89 | 0.06 | -0.20 | 3.29 | 1.26 | -2.99* | -1.22 |
| 5 | $JMSB_5$ 20142 | 2.43 | -2.41 | -0.10 | 0.59** | -2.90 | -1.27 | -4.32** | 0.19 |
| | **SE($g_i$)** | **0.77** | **0.88** | **0.03** | **0.05** | **1.21** | **0.81** | **0.40** | **0.70** |
| | **SE($g_i$-$g_j$)** | **1.09** | **1.25** | **0.04** | **0.06** | **1.70** | **1.14** | **0.56** | **0.99** |
| **Testers** | | | | | | | | | |
| 1 | J-2340 | -5.35* | 3.96 | -0.01 | -0.54** | 7.81* | 4.32 | -10.93** | -3.59 |
| 2 | J-2540 | -10.40** | -2.64 | -0.25** | 0.50** | -3.26 | -0.15 | 3.07* | 1.62 |
| 3 | J-2552 | 16.65** | 6.36* | -0.27** | -0.41** | 5.67 | 1.36 | -4.00** | 1.42 |
| 4 | J-2555 | 12.29** | -3.77 | 0.24** | 0.99** | -5.73 | -3.96 | 2.67* | 4.35* |
| 5 | 85-SB-14 | 12.58** | 1.16 | -0.20 | -0.81** | -2.59 | -1.99 | 3.60** | 0.22 |
| 6 | 81-SB-14 | -7.91** | -8.30** | 0.23 | -0.19 | -5.06 | -2.11 | 0.20 | -1.39 |
| 7 | 149-SB-14 | 3.04 | 2.96 | 0.05 | -1.49** | 5.67 | 2.96 | -0.60 | -4.19* |
| 8 | 150-SB-14 | 6.44** | 10.16** | 0.04 | 1.15** | 6.34 | 0.88 | 3.20** | -0.92 |
| 9 | 158-SB-14 | -27.32** | -9.90** | 0.18* | 0.42** | -8.86* | -1.32 | 2.80* | 2.48 |
| | **SE($g_j$)** | **1.034** | **1.18** | **0.03** | **0.06** | **1.61** | **1.08** | **0.53** | **0.94** |
| | **SE($g_i$-$g_j$)** | **1.47** | **1.67** | **0.05** | **0.09** | **2.28** | **1.53** | **0.75** | **1.32** |

*, ** Significant at 5% and 1% levels, respectively

**Table 3. Hybrids showing significant positive *sca* effects for grain yield and their performance in other traits in pearl millet**

| Sr. No. | Cross | SCA effects | Traits showing useful and significant *sca* effects |
|---|---|---|---|
| 1 | $JMSA_1$ 20141 x 81-SB-14 | 17.58** | EW, EG, TW, HI, FC, ZC, |
| 2 | $ICMA_4$ 10444 x J-2555 | 16.13** | PH, EW, EG, HI, FC, ZC |
| 3 | $JMSA_5$ 20142 x 150-SB-14 | 11.36** | EW, TW, HI |
| 4 | $ICMA_1$ 09555 x 81-SB-14 | 11.02** | PH, EW |
| 5 | $JMSA_5$ 20142 x J-2340 | 10.23** | EW, FC |
| 6 | $ICMA_4$ 10444 x J-2540 | 8.33* | EW, EG, FC |
| 7 | $JMSA_1$ 20141 x 149-SB-14 | 8.18* | PH, TW, HI |
| 8 | $ICMA_4$ 10444 x 149-SB-14 | 7.73* | EW |

*, ** Significant at 5 and 1 per cent levels, respectively.
PH = Plant height, EW = Ear head weight, EG =Ear head girth, TW = Test weight,
HI = Harvest index, FC = Fe content, ZC = Zn content