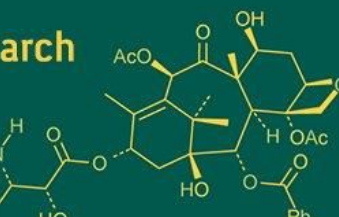
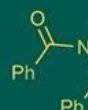


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## Potential general combiners for grain mold resistance in *kharif*-sorghum

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**Abstract**

Grain mold is a significant biological obstacle to enhancing the quality and production of *kharif* sorghum. Mold damage can manifest in various forms, such as discolored grains, diminished grain filling and size, impaired seed germination, the presence of mycotoxins, lowered density and test weight, changed composition of the grain, poor storability, reduced nutritional value, decreased consumer acceptability, and a market price. The present investigation was taken up to find out the general combining ability effects in 45  $F_1$  crosses developed by crossing ten diverse parents having differential reaction to grain mold in half diallel mating design. Study revealed that among the parents, four parents viz., AKGMR 118, CSV 34, AKGMR117 and PDKV Kalyani were appeared to be potential donor parents for exploitation of grain mold resistance as these parents exhibited significant desirable gca effects for germination percentage, threshed grade mold rating along with most of the grain mold resistance contributing traits and grain yield per plant. These parents may be included as a promising good general combiner parent in grain mold resistance breeding programme for improvement of grain mold resistance together with grain yield, which ultimately leads in fetching remunerative price in market.

**Keywords:** Sorghum, grain mold, GCA effects

**Introduction**

Sorghum [*Sorghum bicolor* (L.) Moench] is one of the major millets grown in India, belonging to the family Poaceae. It functions as a versatile crop for nourishment, livestock feed, and energy, and is essential for ensuring food security in rural areas. Grain mold poses one of the significant biological challenges to enhancing the quality and production of *kharif* sorghum. Mold damage can manifest in various forms, including discolored grains, reduced grain filling and size, lower seed germination rates, the presence of mycotoxins, diminished density and test weight, changes in grain composition, poor storability, decreased nutritional value, lower consumer acceptance, and a reduced market price. Various management approaches, including avoidance, the application of fungicides, chemical interventions, and the use of resistant varieties, were implemented to manage grain mold infections. Among them avoidance or chemical control on farmer's field is impracticable. In contrast, the use of resistant varieties is appeared to be cost-effective and efficient method to control grain mold (Mofokeng *et al.*, 2017, Das *et al.*, 2022) [4, 1]. The objective of the present study, is to identify parents that exhibit good combining ability for traits related to resistance to grain mold.

**Materials and Methods**

The research experiment was conducted on the field of Sorghum Research Unit, Dr. P.D.K.V., Akola. The experimental material consisted of ten parents viz., CSV 27, CSV 34, PDKV Kalyani, RMP-42, AKMS 30B, AKMS 14B, GMN-16-3, AKGMR 117, AKGMR 118, B 58586 and 45  $F_1$  crosses. These 45  $F_1$  crosses were developed by crossing ten diverse parents in 10 x 10 half diallel mating design. The experiment was conducted in Randomized block design with three replications. The observations were recorded on five competitive plants for field grade mold rating (FGMR) [1 to 9 scale], threshed grade mold rating (TGMR) [1 to 9 scale], grain hardness, grain density, electrical conductivity of grain leachates, germination percentage, glume coverage percentage, water absorption capacity, fungal load of *Fusarium spp.*, fungal load of *Curvularia spp.* fungal load of other mold spp.

and grain yield per plant. The analysis of combining ability was performed using the mean values across replications for the traits, following method II model 1 as described by Griffing in 1956 [2].

## Results and Discussion

An analysis of combining ability was conducted for all 12 traits of the F<sub>1</sub> crosses and is shown in Table 1. The

variance existing due to treatments was further partitioned using appropriate expectations of the observed mean squares into components of variations attributable to general combining ability (gca) variance.

The estimates of general combining ability effects in desirable direction for the grain mold resistance contributing traits along with grain yield per plant are presented in Table 2.

**Table 1:** Analysis of variance for the combining ability of F<sub>1</sub> crosses in 10 x 10 half diallel

| Sr. No                     | Characters                                         | Sources   |           |       |                    |                    |                                         |
|----------------------------|----------------------------------------------------|-----------|-----------|-------|--------------------|--------------------|-----------------------------------------|
|                            |                                                    | GCA       | SCA       | Error | σ <sup>2</sup> gca | σ <sup>2</sup> sca | σ <sup>2</sup> gca / σ <sup>2</sup> sca |
| Degrees of freedom         |                                                    | 9         | 45        | 108   |                    |                    |                                         |
| 1                          | Field grade mold rating (FGMR) [ 1 to 9 scale]     | 7.908 **  | 0.979**   | 0.084 | 0.652              | 0.895              | 0.729                                   |
| 2                          | Threshed grade mold rating (TGMR) [ 1 to 9 scale]  | 9.313**   | 1.081 **  | 0.106 | 0.767              | 0.975              | 0.787                                   |
| 3                          | Grain Hardness (kg/cm <sup>2</sup> )               | 3.723**   | 0.624**   | 0.037 | 0.307              | 0.587              | 0.523                                   |
| 4                          | Grain density (g/ml)                               | 0.042**   | 0.032**   | 0.001 | 0.003              | 0.031              | 0.112                                   |
| 5                          | Electrical conductivity of grain leachates(ms/ppt) | 0.262**   | 0.037**   | 0.001 | 0.022              | 0.036              | 0.604                                   |
| 6                          | Germination Percentage                             | 200.942** | 29.607**  | 1.807 | 16.595             | 27.801             | 0.597                                   |
| 7                          | Glume coverage (%)                                 | 256.007** | 30.122**  | 0.194 | 21.318             | 29.928             | 0.712                                   |
| 8                          | Water absorption Capacity (g)                      | 0.068 **  | 0.010 **  | 0.001 | 0.006              | 0.009              | 0.640                                   |
| 9                          | Fungal load of <i>Fusarium spp.</i> (%)            | 166.724** | 16.772**  | 0.963 | 13.813             | 15.810             | 0.874                                   |
| 10                         | Fungal load of <i>Curvularia spp.</i> (%)          | 97.953**  | 18.553**  | 0.995 | 8.080              | 17.558             | 0.460                                   |
| 11                         | Fungal load of other mold spp. (%)                 | 14.390**  | 14.606**  | 0.444 | 1.162              | 14.161             | 0.082                                   |
| 12                         | Grain yield per plant (g)                          | 714.77 ** | 197.817** | 4.911 | 59.155             | 192.906            | 0.307                                   |
| ** Significant at 1% level |                                                    |           |           |       |                    |                    |                                         |

From Table 2, it was observed that five parents proved to be best general combining ability for the majority of the traits related to grain mold resistance. The parent AKGMR 118 has been found to possess significant desirable gca effects for all the grain mold resistance characters such as germination percentage, threshed grade mold rating

(TGMR), grain density, grain hardness, electrical conductivity of grain leachates, glume coverage, fungal load of *Fusarium* spp., fungal load of *Curvularia* spp., fungal load of other mold spp. field grade mold rating (FGMR) and water absorption capacity along with grain yield per plant.

**Table 2:** Estimates of general combining ability effects of parents from F<sub>1</sub> crosses

| Sr. No | Parents        | Grain yield per plant (g) | Field grade mold rating (FGMR) [1 to 9 scale] | Threshed grade mold rating (TGMR) [1 to 9 scale] | Grain Hardness (kg/cm <sup>2</sup> ) | Grain density (g/ml) | Electrical conductivity of grain leachates (ms/ppt) | Germination Percentage | Glume coverage (%) | Water absorption Capacity (g) | Fungal load of <i>Fusarium</i> spp. (%) | Fungal load of <i>Curvularia</i> spp. (%) | Fungal load of other mold spp. (%) |
|--------|----------------|---------------------------|-----------------------------------------------|--------------------------------------------------|--------------------------------------|----------------------|-----------------------------------------------------|------------------------|--------------------|-------------------------------|-----------------------------------------|-------------------------------------------|------------------------------------|
| 1      | CSV 27         | 4.950**                   | -0.067                                        | -0.100                                           | -0.049                               | 0.033**              | -0.002                                              | 0.644                  | -3.720 **          | 0.054**                       | 0.396                                   | 1.435**                                   | 0.993**                            |
| 2      | CSV 34         | 6.150**                   | -0.400**                                      | -0.433**                                         | -0.022                               | 0.024*               | -0.012                                              | 2.514 **               | -2.827 **          | -0.007                        | -0.676 *                                | -0.965**                                  | 0.600**                            |
| 3      | PDKV Kalyani   | 3.225**                   | -0.261**                                      | -0.267**                                         | -0.294**                             | 0.081**              | 0.005                                               | 0.731*                 | -0.588 **          | -0.006                        | 0.608 *                                 | -1.231**                                  | 0.445*                             |
| 4      | RMP-42         | -6.247**                  | -0.067                                        | 0.067                                            | -0.051                               | 0.036**              | -0.002                                              | -2.046 **              | 8.243 **           | -0.012                        | 0.331                                   | 1.274**                                   | -0.242                             |
| 5      | AKMS 30B       | -5.139**                  | 1.100**                                       | 1.150**                                          | -0.727**                             | 0.004                | 0.184**                                             | -4.922 **              | -3.834 **          | 0.088**                       | 4.863 **                                | 3.011**                                   | 0.826**                            |
| 6      | AKMS 14B       | -14.486**                 | 1.683**                                       | 1.844**                                          | -0.877**                             | 0.146**              | 0.297**                                             | -8.243 **              | -4.947 **          | 0.140**                       | 6.995 **                                | 4.993**                                   | 0.368*                             |
| 7      | GMN 16-3       | -0.503                    | -0.039                                        | -0.100                                           | 0.158**                              | 0.000                | -0.012                                              | 0.854*                 | 3.690 **           | -0.020*                       | -0.622 *                                | 0.146                                     | 0.397*                             |
| 8      | AKGMR 117      | 1.867**                   | -0.178*                                       | -0.211*                                          | 0.239**                              | 0.011                | -0.104**                                            | 1.594 **               | -1.130 **          | -0.048**                      | -2.415 **                               | -0.665*                                   | 0.505**                            |
| 9      | AKGMR 118      | 13.231**                  | -1.039**                                      | -1.100**                                         | 0.841**                              | 0.027**              | -0.207**                                            | 5.926 **               | -1.611 **          | -0.098**                      | -5.072 **                               | -4.670**                                  | -2.384**                           |
| 10     | B58586         | -3.047**                  | -0.733**                                      | -0.850**                                         | 0.783**                              | 0.001                | -0.146**                                            | 2.947 **               | 6.724 **           | -0.091**                      | -4.408 **                               | -3.327**                                  | -1.508**                           |
|        | SE (m) (gi)    | 0.607                     | 0.079                                         | 0.089                                            | 0.053                                | 0.010                | 0.010                                               | 0.368                  | 0.121              | 0.010                         | 0.269                                   | 0.273                                     | 0.183                              |
|        | CD 5% (gi)     | 1.373                     | 0.179                                         | 0.202                                            | 0.119                                | 0.022                | 0.022                                               | 0.833                  | 0.273              | 0.022                         | 0.608                                   | 0.618                                     | 0.413                              |
|        | CD 1% (gi)     | 1.972                     | 0.257                                         | 0.290                                            | 0.171                                | 0.032                | 0.032                                               | 1.196                  | 0.392              | 0.032                         | 0.873                                   | 0.888                                     | 0.593                              |
|        | SE (m) (gi-gj) | 0.905                     | 0.118                                         | 0.133                                            | 0.078                                | 0.015                | 0.015                                               | 0.549                  | 0.180              | 0.015                         | 0.401                                   | 0.407                                     | 0.272                              |
|        | CD 5% (gi-gj)  | 2.047                     | 0.267                                         | 0.301                                            | 0.177                                | 0.033                | 0.033                                               | 1.241                  | 0.407              | 0.033                         | 0.906                                   | 0.921                                     | 0.616                              |
|        | CD 1% (gi-gj)  | 2.940                     | 0.384                                         | 0.432                                            | 0.255                                | 0.048                | 0.047                                               | 1.783                  | 0.584              | 0.048                         | 1.302                                   | 1.323                                     | 0.884                              |

Another parent B58586, transmitted favourable genes for almost all the grain mold resistance characters except for grain density and grain yield per plant. It has recorded desirable significant gca effects for germination percentage, threshed grade mold rating (TGMR), grain hardness, electrical conductivity of grain leachates, fungal load of *Fusarium* spp., fungal load of *Curvularia* spp., fungal load

of other mold spp., field grade mold rating (FGMR) and water absorption capacity.

The parent CSV 34 was found to be good combiner for most the grain mold resistance characters except for grain hardness, electrical conductivity of grain leachates, fungal load of other mold spp. and water absorption capacity. The parent CSV34 has been found to possess significant desirable gca effects for germination percentage, threshed

grade mold rating (TGMR), grain density, fungal load of *Fusarium* spp., fungal load of *Curvularia* spp. and field grade mold rating (FGMR) along with grain yield per plant. The parent AKGMR 117 was found to be good combiner for almost all the grain mold resistance characters along with grain yield per plant. The parent AKGMR 117 has been found to possess significant desirable gca effects for germination percentage, threshed grade mold rating (TGMR), grain hardness, electrical conductivity of grain leachates, glume coverage, fungal load of *Fusarium* spp., fungal load of *Curvularia* spp., fungal load of other mold spp. field grade mold rating (FGMR) and water absorption capacity.

The parent PDKV Kalyani, transmitted favourable genes for the grain mold resistance characters along with grain yield per plant. It has recorded desirable significant gca effects for germination percentage, threshed grade mold rating (TGMR), grain density, glume coverage, fungal load of *Curvularia* spp. and field grade mold rating (FGMR).

Similarly, the parents viz., AKGMR 118, CVS 34, CSV 27, PDKV Kalyani and AKGMR 117 showed significant desirable gca effects for grain yield per plant. and found to be the best general combiner for grain yield per plant. (Table 2) .

Thus, from summary performance of gca effects for grain mold resistance traits, from the above-mentioned parents four parents viz., AKGMR 118, CSV34, AKGMR 117 and PDKV Kalyani can be categorized as good general combiners for grain mold resistant traits along with grain yield per plant and may be utilize as a source of desirable gene in future breeding programme to exploit additive gene effects. Though the parent B58586 had negative gca effects for grain yield, but it had exhibited significant desirable gca effects for germination percentage, threshed grade mold rating along with most of the grain mold resistance contributing traits. Hence it may be included as a promising good general combiner parent in grain mold resistance breeding programme. Rao *et al.* (2016) <sup>[5]</sup>, Ingole *et al.* (2018) <sup>[3]</sup> and Wawkar *et al.* (2023) <sup>[6]</sup> in their study also reported potential good combiners on the basis of GCA effects for grain mold resistance contributing traits.

Since a high general combining effects correspond with additive and additive x additive interaction (Griffing 1956) <sup>[2]</sup> and represents the fixable genetic component of variation, hence these parents are considered valuable for use in recombination breeding programs.

## Conclusion

The general combining ability effects for grain mold resistance traits, of the four parents viz., AKGMR 118, CSV34, AKGMR 117 and PDKV Kalyani can be categorized as good general combiners for grain mold resistant traits along with grain yield per plant and may be utilize as a source of desirable gene in future breeding programme to exploit additive gene effects. Additive and additive x additive interaction (Griffing 1956) <sup>[2]</sup> and represents the fixable genetic component of variation, hence these parents may be utilized in recombination breeding programme for development of grain mold resistance along with grain yield.

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