Combining ability analysis for seed protein and methionine content in green gram [Vigna radiata (L.) wilczek]

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ABSTRACT

For combining ability analysis, a diallel method was employed in which eight genotypically diverse lines of green gram were crossed among themselves in all possible combinations excluding reciprocals. The analysis for combining ability revealed significant mean sum of squares of both general combining ability (GCA) and specific combining ability (SCA) for most of the characters which indicated the presence of both additive and non-additive gene actions. Higher magnitude of GCA effects than SCA effects were observed for days to secondary branches per plant, 100 seeds weight and seed yield per plant indicating predominance of these traits by additive gene effects. Higher magnitude of SCA effects than GCA effects were observed for characters pod length, seed protein content and seed methionine content pointed out to be the preponderance of non-additive gene effects in the expression of these characters. The good general combiner for seed yield was BM-4, whereas, IPM 99-125 was most promising for seed protein content and RMG-1045 for seed methionine content. The best specific cross combinations for seed yield and seed methionine content was BM-4 x PDM-139 and for seed protein content cross RMG-1035 x RMG-1045. These parents and cross combinations could be utilized for further breeding programme for improvement in yield and quality of mungbean.

Key words: Diallel analysis, GCA, Mungbean, Quality traits, SCA, Yield components.

INTRODUCTION

Pulses constitute an important ingredient of the vegetarian diet in the Indian sub-continent and play a significant role in Indian farming, providing quality food to teeming million and restoring soil fertility through biological nitrogen fixation. India is the largest producer and consumer of pulses in the world and mungbean is the most important legume crop in India after chick pea. India is the primary green gram producer and contributes to about 75 per cent of the world pulses production. In India, pulses are grown in an area of 25.4 million hectare area with production status of nearly 19.66 million tonnes at an average productivity level of 770 kg/ha. Among various pulse crops grown in India, green gram is grown on an area of 2.75 million hectares with production 1.19 million tonnes and productivity of 436 kg/ha (Anonymous, 2013-14). In Rajasthan, it was grown on 965.6 thousand hectares with a production status of 453.6 thousand tonnes and yield of 470 kg/ha (Commissionerate of Agriculture, Rajasthan-Jaipur,2015-16). It contains 25.0 per cent proteins with all essential amino acids, which is almost three times more than that of cereals (Saini et al., 2010). The country has experienced progressive decline in per capita availability of pulses per day from 70.3 g in 1956 to 41.9 g in 2013 (Anonymous, 2014). This decline is mainly attributed to the steady marginalization of their cultivation in the wake of the green revolution, meagre productivity advances and burgeoning population. It generally felt that there is an urgent need to break the bottleneck for increasing productivity of this crop. For any successful breeding programme to improve grain yield and component characters, it is essential to know precisely the genetic architecture of these characters under prevailing conditions. Serious attention is required to develop high yielding varieties of green gram using various crop breeding techniques. The diallel cross analysis technique (Griffing, 1956) could be used as one of the approaches to identify superior parents and crosses. Methionine is an essential sulphur containing amino acid in humans and can not be synthesized by the body itself, furthermore methionine plays an important role in the synthesis of other proteins. So, study of methionine and protein is very important. The combining ability determined through diallel analysis is useful to assess the nicking ability of the parents and at the same time it elucidates the nature and magnitude of different types of gene actions involved. In this context, combining ability analysis is useful in isolating superior genotypes and in identifying gene action involved in the inheritance of characters of economic importance. Combining ability analysis provides clues to the usefulness of individuals to be employed as the parents in the hybridization programme

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as well as simultaneously to screen the hybrids. GCA effects and additive x additive gene action are theoretically fixable, where as SCA attributed to non additive gene action may be due to dominance or epistasis or both and is not fixable. Thus based on such information breeder can spot superior donor parents having high GCA effect and per se performance and also identifying promising crosses for use in improvement work.

MATERIALS AND METHODS

The experimental material for the present investigation comprised of 36 entries including 8 parents and their 28 F1 crosses. Eight homozygous namely IPM-99-125, BM-4, ML-131, IPM 02-03, PDM-139, RMG-1035, RMG-344 and RMG-1045 but highly diverse and well adapted genotypes of green gram were selected as parents for crossing programme (Table 1.). Cross success percentage was less in open field at normal environmental condition; therefore crosses were attempted at green house during spring, 2013-14 in diallel fashion (excluding reciprocals) to obtain 28 F1 crosses. These parents and F1’s were grown in randomized block design with three replications during kharif, 2014 at RCA college farm, MPUAT, Udaipur. Sowing was done by dibbling the seeds at a distance of 10 cm in the rows of 2 m length with row to row spacing of 30 cm. All recommended cultural practices were adopted to raise a good crop. The data on ten randomly selected competitive plants in 8 parents and 28 F1’s per treatment per replication were recorded for six quantitative and two qualitative traits. The combining ability analysis was carried out according to Griffing’s (1956) method 2 (Parents and one set of F1’s without reciprocals) and Model-I (fixed effects).

RESULTS AND DISCUSSION

The concept of combining ability analysis has significant practical implication in plant breeding as it allows the prediction of the relative efficiency of parents based on early generation performance besides enabling to study the comparative performance of lines in hybrid combinations. In self-pollinated crop like green gram where pure line breeding is a thumb rule, crosses with high mean and SCA effects are more likely to show transgressive segregation and lead to development of superior pure lines. The analysis of variance for experimental design was performed for eight quantitative and quality characters (Table 2.). It revealed significant differences for all the characters indicating presence of adequate genetic variation among the genotypes. Further partitioning of mean squares due to parents and F1’s were significant for all the characters, revealed that adequate amount of variation was present for parents and F1’s. However, mean squares due to Parent v/s hybrid component were significant for pods per cluster, 100-seed weight, seed protein content and seed methionine content, which depicted presence of high heterosis for these characters. The analysis

Table 1: Name, pedigree and source of the parents used for research work

| Parent      | Pedigree               | Source     |
|-------------|------------------------|------------|
| IPM 99-125  | PM 3 x APM 36          | IPR, Kanpur|
| BM 4        | MUTANT of T44          | ARS, Badnapur|
| ML 131      | ML 1 x ML 23          | ARS, Durgapura|
| IPM 02-03   | IPM 99-125 x Pusa bold 2 | IPR, Kanpur|
| PDM 139     | ML 20/19 x ML 5       | IPR, Kanpur|
| RMG 1035    | RMG 492 x ML 818      | ARS, Durgapura|
| RMG 344     | MOONG SEL.1 x J 45   | RAU, Durgapura|
| RMG-1045    | RMG-62 x KM 2170     | RAS, Durgapura|

Table 2: Analysis of variance showing mean squares for eight characters in green gram

| Characters                  | Rep [2] | Genotype [35] | Parent [7] | F1 [27] | P vs F1 [1] | Error [70] |
|-----------------------------|---------|---------------|------------|---------|-------------|------------|
| Days to maturity            | 22.99   | 38.68 **      | 59.63 **   | 33.71 **| 26.09       | 14.59      |
| Secondary branches / plant  | 1.06    | 1.66 **       | 1.35 **    | 1.8 **  | 0.06        | 0.43       |
| Pods / cluster              | 0.05    | 0.34 **       | 0.32 **    | 0.34 ** | 0.60**      | 0.07       |
| Pod length                  | 0.43    | 2.53 **       | 0.53 *     | 3.13 ** | 0.14        | 0.61       |
| 100 Seed weight             | 0.11    | 1.36 **       | 0.66 **    | 1.49 ** | 2.94**      | 0.16       |
| Seed yield / plant          | 1.89    | 4.57 **       | 9.31 **    | 3.49 ** | 0.25        | 0.69       |
| Seed protein content        | 0.38    | 4.6 **        | 1.42 **    | 5.51 ** | 2.27**      | 0.25       |
| Seed methionine content     | 0.01    | 0.02 **       | 0.01 **    | 0.02 ** | 0.03**      | 0.01       |

Table 3: Analysis of variance showing mean squares for eight characters in green gram

| Characters                  | GCA [7] | SCA [28] | Error [70] |
|-----------------------------|---------|----------|------------|
| Days to maturity            | 24.72   | 9.93 **  | 4.86       |
| Secondary branches / plant  | 1.82    | 0.24     | 0.14       |
| Pods / cluster              | 0.06    | 0.13 **  | 0.02       |
| Pod length                  | 0.49    | 0.93 **  | 0.20       |
| 100 Seed weight             | 0.70    | 0.39     | 0.05       |
| Seed yield / plant          | 6.52    | 0.27     | 0.23       |
| Seed protein content        | 0.55    | 1.78 **  | 0.08       |
| Seed methionine content     | 0.01    | 0.01 **  | 0.011      |
| Crosses                     | Days to Maturity | Secondary Pods / cluster | Pod length | 100 Seed Weight | Seed yield / plant | Protein content | Semithionine content |
|----------------------------|------------------|----------------------------|------------|----------------|-------------------|----------------|---------------------|
| IPM 99-125 X BM-4          | 1.83             | 0.30                       | 0.11       | -0.34          | 1.63**            | 0.54           | 1.06**              |
| IPM 99-125 X ML-131        | -1.83            | -0.08                      | -0.34 *    | -1.08          | 1.54**            | 0.40           | -2.68**             |
| IPM 99-125 X IPM-02-03     | 1.81             | -0.14                      | -0.08      | 0.23           | -0.94**           | -0.50          | 0.42                |
| IPM 99-125 X PDM-139       | -1.06            | 0.17                       | -0.64 **   | -0.24          | -0.77**           | 0.12           | -2.13 **            |
| IPM 99-125 X RMG-1035      | -1.27            | -0.85 *                    | 0.3 *      | 0.94 *         | -0.05             | -0.51          | -0.39               |
| IPM 99-125 X RMG-344       | 0.47             | -0.09                      | 0.22       | 0.43           | -0.22             | -0.09          | 0.98 **             |
| IPM 99-125 X RMG-1045      | -6.73 **         | 0.39                       | 0.09       | -0.86 *        | -0.79**           | -0.63          | 1.46 **             |
| BM-4 X ML-131              | -4.11 *          | 0.20                       | -0.2       | 1.40 **        | -0.71**           | 0.35           | -0.68 *             |
| BM-4 X IPM-02-03           | 0.07             | 0.22                       | -0.36 **   | 2.28 **        | 0.05              | -0.44          | 0.49                |
| BM-4 X PDM-139             | 2.29             | 0.30                       | -0.07      | -0.01          | 0.09              | 0.51 *         | 0.09                |
| BM-4 X RMG-1035            | -4.12 *          | -0.29                      | 0.24       | -1.63 **       | -0.44 *           | -0.39          | 0.45                |
| BM-4 X RMG-344             | 0.89             | 0.13                       | 0.43 **    | -0.85 *        | 0.26              | -0.26          | -2.20 **            |
| BM-4 X RMG-1045            | -0.13            | -0.26                      | -0.48 **   | -0.24          | -0.62**           | -0.18          | 0.83                |
| ML-131 X IPM-02-03         | 3.15             | 0.12                       | 0.08       | 0.76           | -0.47*            | 0.21           | -1.22 **            |
| ML-131 X PDM-139           | -2.55            | 0.44                       | -0.4 **    | 0.96 *         | -0.20             | 0.37           | 0.59 *              |
| ML-131 X RMG-1035          | 1.68             | -0.46                      | 0.39 **    | -0.53          | -0.20             | 0.29           | 1.21 **             |
| ML-131 X RMG-344           | -8.27 **         | -0.07                      | -0.35 *    | -0.75          | -0.20             | -0.40          | 1.90 **             |
| ML-131 X RMG-1045          | 2.13             | -0.23                      | 0.05       | 0.86 *         | -0.40             | -0.41          | -0.64 *             |
| IPM-02-03 X PDM-139        | -1.15            | 0.30                       | 0.36 **    | -1.61 **       | 0.13              | -0.06          | 0.44                |
| IPM-02-03 X RMG-1035       | 0.51             | -0.93 *                    | -0.49 **   | 0.53           | 0.72              | -0.53 *        | 0.07 **             |
| IPM-02-03 X RMG-344        | -0.56            | -0.17                      | 0.31 *     | 0.30           | 0.07              | -0.13          | 0.84 **             |
| IPM-02-03 X RMG-1045       | 0.55             | 0.16                       | -0.09      | -0.89 *        | -0.06             | -0.11          | -2.59 **            |
| PDM-139 X RMG-1035         | -0.26            | 0.08                       | -0.04      | 0.84 *         | -0.04             | 0.48           | 0.28                |
| PDM-139 X RMG-344          | -0.59            | 0.34                       | -0.25      | -0.16          | -0.38             | -0.32          | -1.53 **            |
| PDM-139 X RMG-1045         | 3.35             | -0.70 *                    | -0.5 **    | 0.23           | 0.42 *            | 0.63           | 0.06                |
| RMG-1035 X RMG-344         | 0.42             | -0.27                      | -0.26      | -0.67          | -0.21             | -0.40          | 0.67 *              |
| RMG-1035 X RMG-1045        | 2.39             | 1.30 **                    | 0.02       | -0.66          | -0.23             | 1.04 *         | 1.52 **             |
| RMG-344 X RMG-1045         | 3.76             | 0.44                       | 0.33 *     | 1.29 **        | 0.40              | 1.22 *         | -0.86 **            |

C. D. Comparisons

| Sij at 95%       | 4.10 | 0.70 | 0.13 | 0.84 | 0.21 | 0.89 | 0.26 | 0.02 |
|------------------|------|------|------|------|------|------|------|------|
| Sij—Sik at 95%   | 6.07 | 1.04 | 0.20 | 1.24 | 0.31 | 1.32 | 0.39 | 0.04 |
| Sij—Skl at 95%   | 5.72 | 0.98 | 0.19 | 1.17 | 0.30 | 1.25 | 0.36 | 0.03 |
of variance for combining ability of each character is presented in Table 3. Mean squares due to GCA were significant for all the attributes, whereas mean squares due to SCA were significant for all the characters except for seed yield per plant. Higher magnitude of GCA effects than SCA effects were observed for days to maturity, days to secondary branches/plant, 100 seeds weight and seed yield/plant indicating predominance of these traits by additive gene effects. Higher magnitude of SCA effects than GCA effects were observed for characters pods per cluster, pod length, seed protein content and seed methionine content. Similar to the present findings, Singh et al. (2007), Rehman et al. (2010) and Patil et al. (2011) recorded importance of additive gene effects in green gram.

**General and specific combining ability effects:** The results pertaining to general combining ability effects of the parents and specific combining ability effects of the crosses were estimated separately and are presented in Table 4 and Table 5. Variable results were observed with regard to GCA and SCA effects for different characters. Only one parent RMG-1045 exhibited negative significant GCA effect for days to maturity, indicating as good combiners for days to 50% flowering. However, four crosses exhibited significant negative SCA effects. The highest significant negative SCA effects were exhibited by cross ML-131 x RMG-344 followed by cross IPM 99-125 x RMG-1045 and PM-4 x RMG-1035(Table 4). Aher et al (2001) and Kumar et al. (2010) also identified similar result.

For secondary branches per plant significant positive GCA effects exhibited by one parent BM-4. Out of four significant crosses, only one cross RMG-1035 x RMG-1045 showed positive significant specific combining ability effects (Table 5). Manivannan (2002) and Barad et al. (2008) also identified good general combiners for these traits in green gram. For pods per cluster only parent RMG-1035 recorded highly significant positive GCA effects. Estimates of specific combining ability effects showed that out of fourteen significant crosses, six crosses showed positive significant specific combining ability effects. However, cross BM-4 x RMG-344 followed by cross ML-131 x RMG-1035 and IPM 02-03 x PDM-139 recorded the highest significant positive SCA effects depicted in Table-5. Kute and Deshmukh (2002) and Gupta et al. (2006) also recorded the similar results.

ML-131 exhibited significant positive GCA effects for pod length and recorded as good general combiner for this trait. SCA effects revealed that the crosses BM-4 x IPM 02-03 and BM-4 x ML-131 were positively high significant. For 100-seed weight, IPM 99-125 exhibited highest significant positive GCA effect for this trait (Table 5). Estimates of SCA effects revealed that the cross IPM 99-125 x BM-4 depicted the highest significant positive SCA effects for 100-seed weight. Similar result has been found
by Gupta et al. (2006) and Ajmal et al. (2007). Four parents revealed significant positive GCA effects for seed yield per plant (Table 4) and these were BM-4, PDM-139, ML-131 and IPM 99-125. Estimates of SCA effects revealed that three crosses exhibited positive significant SCA effects. The cross RMG-344 x RMG-1045 depicted maximum positive SCA effects for seed yield per plant (Table 4). Intwala et al. (2009) and Jayamani and Sathy (2011) also identified superior combiners for grain yield in their green gram material.

Parents IPM 99-125 and RMG-1035 displayed significant positive GCA effects in F₁’s for seed protein content hence appeared as the best combiners (Table 5). Ten crosses depicted significant positive SCA effects for the trait. The hybrid ML-131 x RMG-344 displayed the highest SCA effect for protein content followed by RMG-1035 x RMG-1045. Aher et al. (1999) and Dasgupta et al. (1998) also identified superior general and specific combiners for seed protein content in green gram. Parents ML-131, IPM 02-03 and RMG-1045 showed significant positive gca effects for seed methionine content. Seven crosses depicted significant positive SCA effects and hybrid BM-4 x PDM-139 showed the highest seed methionine content followed by cross PDM-139 x RMG-344 (Table 4).

CONCLUSION

This research has been conducted to identify superior parents as a best combiner best and superior crosses as a specific combiners for different characters on the basis of various parameters viz. per se performance, GCA effects, SCA effects and superiority of F₁ over mid and better parent (Table 6). An overall appraisal of GCA effects revealed that parents IPM 99-125 and BM-4 were good combiners for the majority of characters. Whereas, for seed protein content cross RMG-1035 x RMG-1045 appeared promising and parent RMG-1035/ IPM 99-125 as best general combiner with high mean values. Similar to grain yield, cross BM-4 x PDM-139 also appeared promising for seed methionine content and parent ML-131 as good combiner with high mean values. Thus, these parents and cross combinations could be utilized for further use in breeding programme for improvement in yield and quality of mungbean.

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