Original Research Article

Genetic Correlation between Various Traits in F₂ Populations Derived from Crosses Involving Specialty Varieties of Rabi Sorghum

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A B S T R A C T

The genetic nature of character association for various traits was studied in Rabi sorghum using F₂ populations derived from four crosses of M 35-1 with specialty varieties viz., AKJ-1 (flaking), KMJ-1 (popping), and SMJ-1 & RSJ-1 (hurda purpose). These varieties derived from landraces are recommended for cultivation in Northern Dry Zone of Karnataka. Grain yield per plant and fodder yield per plant were significantly and positively correlated with all the yield components studied plant height, panicle length, panicle breadth, panicle weight and 100 seed weight in the crosses M 35-1 x AKJ-1 and M 35-1 x KMJ-1. Positive and significant association was observed among these yield components in these crosses. Where as in the cross M 35-1 x RSJ-1 the association of grain yield per plant with all the above yield parameters was non-significant and in M 35-1 x SMJ-1 the association was significant only with plant height and panicle length. Days to 50% flowering was significantly negatively correlated with all the yield components in all the crosses except in the cross M 35-1 x KMJ-1. 100 seed weight was significantly positively associated with all other yield parameters in all the crosses except M 35-1 x KMJ-1 with non-significant and negative association with panicle length. In this cross, seed size in terms of 100 seed weight was significantly negatively correlated with popping expansion ratio and panicle length was positively correlated with popping quality traits studied viz., popping yield, popping expansion ratio and flake size. The results indicate the scope for isolating desirable segregants with high yield and earliness in the cross M 35-1 x AKJ-1. Where as in the cross M 35-1 x KMJ-1, panicle length can be used as indirect selection criteria for isolating desirable segregants. KMJ-1 was characterized by significantly higher panicle length compared to all other parents used in the study.

Keywords
Rabi sorghum, Sorghum bicolor, Correlations, Genotypes, Yield and yield component traits, hurda, F₂ population, Value addition

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Introduction

Sorghum is one of the most important cereal crop in the world because of its adaptation to a wide range of ecological conditions, suitability for low input cultivation and diverse uses. Sorghum ranks third among the major food grain crops of our country. Besides a major source of staple food for humans, it serves as an important source of cattle feed and fodder. The greatest merit with jowar is that it has capacity to withstand drought.

In India, Maharashtra, Karnataka and Madhya Pradesh being the largest sorghum producing states. It is cultivated over an area of 5.2 million hectares with an annual production of 3.75 million tonnes and productivity of 720 kg/ha (Anon., 2018).
In Karnataka, it is cultivated in 1.09 million ha with an annual production of 1.26 million tonnes of grain with a productivity of 1162 kg/ha (https://aps.dac.gov.in/APY/Public_Report1.aspx; 2017-18). In India, sorghum is cultivated in both the kharif and rabi seasons. The rabi sorghum in Karnataka accounts for major share of total sorghum area (91.3%) under cultivation in the state and total production (87.5%).

Sorghum constitutes a source of calories, protein and minerals. Sorghum grain contains about 10-12% protein, 3% fat, and 70% carbohydrates. Progress has been made in developing high yielding varieties and hybrids with improved agronomic traits that resulted in excess production. Sorghum produced in India is consumed mostly in the form of roti (unleavened bread) and sankati (thick porridge). To some extent it is also eaten as parched and popped grain. Rabi sorghum (post-rainy) being the staple and nutritious cereal of Northern dry zone of Karnataka is characterized by excellent grain quality and tasty grains and fetches high price in the market.

During the course of rabi sorghum cultivation in northern belt of Karnataka, genotypes with specialty grain types have been evolved due to farmers selection for suitability for specific food purposes like kadabina jola (for steamed food ‘kadabu’), aralina jola (for pops), seethani jola (for roasted tender grain), etc. (Sajjanar et al., 2010; Patil et al., 2010).

The genotypes have been identified for specific food purposes in these categories of speciality grain varieties viz., AKJ-1 for flaking (kadabina jola), KMJ-1 for popping (aralina jola) and SMJ-1 & RSJ-1 with sweet grains for hurda/seethani (seethani jola) (Sajjanar et al., 2011a, Sajjanar et al., 2011b, Biradar et al., 2011a and Biradar et al., 2011b). Studies on these genotypes showed that these genotypes are rich in grain antioxidants, and micronutrients (Keshavreddy et al., 2010).

These special genotypes are with lower yielding ability and hence there is a need to improve yielding ability while maintaining their distinct grain quality traits. Knowledge of interrelationship between yield and yield attributing components enables the breeders to plan the breeding programme accordingly. The phenotype of a plant is the result of interaction of a large number of factors. Final yield is the sum of effect of several component factors. Correlation studies provide information on the nature and extent of association between any two pairs of metric characters. Grafius (1959) opined that there may not be any gene for yield as such but operates only through its components. Correlation studies will surely help to identify the character to make selections for higher yield with a view to determine the extent and nature of relationship among the yield contributing characters.

Materials and Methods

The experimental material consisted of F2 populations derived from four crosses involving M 35-1, a popular rabi sorghum variety and four specialty varieties of rabi sorghum viz., AKJ-1 (flaking variety), KMJ-1 (popping variety), and SMJ-1 & RSJ-1 (hurda varieties). All the special varieties except RSJ-1 were released for cultivation in northern dry zone of Karnataka (The Gazette of India, 2018) for value addition in Rabi sorghum. All the varieties are with semi-compact panicle except RSJ-1 with compact panicle. KMJ-1 was characterized by long panicle with black glumes covering white seeds, and AKJ-1 with red glumes and seeds. Fresh F1 crosses viz., M 35-1 x AKJ-1, M 35-1 x KMJ-1, M 35-1 x SMJ-1 and M 35-1 x RSJ-1 were made by hand emasculation and...
pollination, and F1s were advanced to F2 by selfing during Rabi 2014-15 under AICSIP, RARS, Vijayapur. The Parents (P1 and P2) and F1 were planted in two rows each, and F2 populations in 20 rows each were planted in four meter length with a row spacing of 60 × 15 cm and in two replications during Rabi 2015-16 at AICSIP, Regional Agricultural Research Station, Vijayapur.

In both the replications, five plants in each of parents and F1, all plants in F2 generation were tagged for recording observations. Fertilizer applied was 8.7 g of urea per m² and 5.4 g of DAP per m². Thinning operation was carried out at 10 days after seedling emergence to ensure optimum number of plants. Observations were recorded on all tagged plants for all the four crosses for days to 50% flowering, plant height (cm), Panicle length (cm), panicle weight (g), 100 seed weight (g), grain yield per plant (g) and fodder yield per plant (g). In the cross M 35-1 x KMJ-1, additional observations were recorded for popping quality traits viz., popping yield (%), expansion ratio (ml/g) and flake size (ml) (ratio of popped grain volume to that of number of seeds per gram).

**Results and Discussion**

**Yield**

In the crosses M 35-1 × KMJ-1 and M 35-1 × AKJ-1, grain yield was found to be significantly and positively correlated with, plant height, panicle length, panicle breadth, panicle weight and 100 grain weight. In the cross M 35-1 × SMJ-1, significant and positive association for grain yield was found only with traits, plant height and panicle length. However, in the cross M 35-1 × RSJ-1, none of the component traits were significantly associated with grain yield. With respect to days to 50% flowering, none of the crosses showed significant association with grain yield. Regarding popping traits in the cross M 35-1 × KMJ-1, grain yield was found to be significantly and positively correlated with, popping yield and flake size. In this cross, grain yield per plant was significantly positively correlated with fodder yield per plant.

Mallinath et al., (2004) reported in correlation studies that grain yield per plant was found to be significantly and positively associated with panicle weight and fodder yield per plant, Bohra et al., (1986) for panicle length and Vijayanur et al., (2012) and Seetharam and Ganeshmurthy (2013) for panicle weight. Panicle breadth was significantly positively associated with grain yield per plant only in the crosses M 35-1 × KMJ-1 and M 35-1 x AKJ-1. The positive association between panicle breadth and grain yield per plant is justifiable as broad panicles will have more secondary branches.

In all the crosses except M 35-1 x SMJ-1 fodder yield per plant was found to be significantly and positively correlated with plant height, panicle length, panicle breadth, panicle weight and 100 grain weight. With grain yield per plant, fodder yield per plant was significantly and positively associated only in cross M 35-1 × KMJ-1.

Fodder yield per plant has direct effect on grain yield per plant (Mallinath et al., 2004). In this cross, fodder yield per plant was found to be significantly and positively correlated with popping expansion ratio. In M 35-1 × AKJ-1 and M 35-1 × SMJ-1, fodder yield per plant was found to be significantly negatively correlated with days to 50% flowering. However, in the cross M 35-1 × SMJ-1, fodder yield per plant was found to be significantly and positively correlated with panicle breadth, panicle weight and 100 grain weight (Table 1–4).
Table 1 Correlation coefficients between yield and yield components in F₂ population of cross M35-1 × KMJ-1 in *rabi* sorghum

|                           | Days to 50% flowering | Plant height | Panicle length | Panicle breadth | Panicle weight | 100 seed weight | Grain yield per plant | Fodder yield per plant | Popping yield | Expansion ratio | Flake Size |
|---------------------------|------------------------|--------------|----------------|----------------|----------------|------------------|------------------------|-------------------------|--------------|-----------------|------------|
| Days to 50% flowering     | 1                      |              |                |                |                |                  |                        |                         |              |                 |            |
| Plant height              | 1                      | 0.172**      | 0.027          | -0.043         | -0.072         | 0.015            | 0.014                  | 0.004                   | -0.019        | 0.008           | 0.045      |
| Panicle length            | 1                      | 0.486**      | 0.247**        | 0.476**        | 0.154**        | 0.434**          | 0.369**                | 0.025                   | 0.001         | 0.071           |            |
| Panicle breadth           | 1                      | 0.271**      | 0.481**        | -0.002         | 0.339**        | 0.246**          | 0.143**                | 0.097**                 | 0.106**       |                 |            |
| Panicle weight            | 1                      | 0.424**      | 0.186**        | 0.312**        | 0.108**        | 0.016            | -0.022                 | 0.036                   |              |                 |            |
| 100 seed weight           | 1                      | 0.265**      | 0.755**        | 0.212**        | 0.101**        | 0.036            | 0.155**                |                         |              |                 |            |
| Grain yield per plant     | 1                      | 0.375**      | 0.090*         | 0.027          | -0.095*        |                  |                        |                         |              |                 | 0.069      |
| Fodder yield per plant    | 1                      | 0.212**      | 0.101*         | 0.02           | 0.175**        |                  |                        |                         |              |                 |            |
| Popping yield             |                         |              |                |                |                |                  |                        |                         |              |                 |            |
| Expansion ratio           |                         |              |                |                |                |                  |                        |                         |              |                 |            |
| Flake Size                |                         |              |                |                |                |                  |                        |                         |              |                 |            |

** significant at the 0.01 level (2-tailed).
* significant at the 0.05 level (2-tailed).
Table 2 Correlation coefficients between yield and yield components in F$_2$ population of cross M35-1 × RSJ-1 in *rabi* sorghum

|                       | Days to 50% flowering | Plant height | Panicle length | Panicle breadth | Panicle weight | 100 seed weight | Grain yield per plant | Fodder yield |
|-----------------------|-----------------------|--------------|----------------|-----------------|----------------|------------------|------------------------|--------------|
| Days to 50% flowering | 1                     | -0.242**     | -0.464**       | -0.279**        | -0.327**       | -0.264**         | 0.098                  | -0.106       |
| Plant height          |                       |              |                |                 |                |                  |                        |              |
|                       | 1                     | 0.760**      | 0.558**        | 0.643**         | 0.468**        | 0.116            | 0.285**                |              |
| Panicle length        |                       |              |                |                 |                |                  |                        |              |
|                       | 1                     | 0.576**      | 0.670**        | 0.522**         | 0.032          |                  |                        | 0.245**      |
| Panicle breadth       |                       |              |                |                 |                |                  |                        |              |
|                       | 1                     | 0.734**      | 0.579**        | -0.042          | 0.316**        |                  |                        |              |
| Panicle weight        |                       |              |                |                 |                | 0.116            | 0.285**                |              |
|                       | 1                     | 0.636**      | 0.067          | 0.378**         |                |                  |                        |              |
| 100 seed weight       |                       |              |                |                 |                | 1                | 0.044                  | 0.545**      |
| Grain yield per plant |                       |              |                |                 |                |                  |                        | 0.088        |
| Fodder yield          |                       |              |                |                 |                |                  |                        | 1            |

**significant at the 0.01 level (2-tailed).

* significant at the 0.05 level (2-tailed).
Table 3 Correlation coefficients between yield and yield components in F₂ population of cross M35-1 × AKJ-1 in *rabi* sorghum

|                          | Days to 50% flowering | Plant height | Panicle length | Panicle breadth | Panicle weight | 100 seed weight | Grain yield per plant | Fodder yield |
|--------------------------|-----------------------|--------------|----------------|----------------|----------------|-------------------|-----------------------|--------------|
| Days to 50% flowering    | 1                     | -0.178 **    | -0.375 **      | -0.260 **      | -0.198 **      | -0.221 **         | -0.118 **             | -0.136 **    |
| Plant height             | 1                     | 0.604 **     | 0.391 **       | 0.447 **       | 0.433 **       | 0.453 **          | 0.254 **              |
| Panicle length           | 1                     | 0.564 **     | 0.572 **       | 0.460 **       | 0.382 **       | 0.278 **          |
| Panicle breadth          | 1                     | 0.737 **     | 0.499 **       | 0.248 **       | 0.182 **       |
| Panicle weight           | 1                     | 0.719 **     | 0.255 **       | 0.168 **       |
| 100 seed weight          | 1                     | 0.258 **     | 0.230 **       |
| Grain yield per plant    | 1                     |              |                |                | 0.109          |
| Fodder yield             | 1                     |              |                |                |                |

** significant at the 0.01 level.

* significant at the 0.05 level
**Table 4** Correlation coefficients between yield and yield components in F2 population of cross M35-1 × SMJ-1 in *rabi* sorghum

|                          | Days to 50% flowering | Plant height | Panicle length | Panicle breadth | Panicle weight | 100 seed weight | Grain yield per plant | Fodder yield |
|--------------------------|------------------------|--------------|----------------|----------------|----------------|------------------|------------------------|--------------|
| Days to 50% flowering    | 1                      | -0.082       | -0.203**       | -0.258**       | -0.377**       | -0.360**         | -0.051                | -0.173**     |
| Plant height             | 1                      | 0.403**      | 0.157*         | 0.229**        | 0.260**        | 0.296**          | 0.084                  |
| Panicle length           | 1                      | 0.231**      | 0.241**        | 0.095          | 0.143*         | 0.100            |                        |
| Panicle breadth          | 1                      | 1.633**      | 1.438**        | 0.056          | 0.198**        |                  |                        |
| Panicle weight           | 1                      | 0.695**      | -0.052         | 0.301**        |                |                  |                        |
| 100 seed weight          | 1                      |               | 0.016          | 0.314**        |                |                  |                        |
| Grain yield per plant    | 1                      |               |               |                | 0.038          |                  |                        |
| Fodder yield             | 1                      |               |               |                |                |                  |                        |

**significant at the 0.01 level (2-tailed).

* significant at the 0.05 level (2-tailed).
Seed size

In all the crosses, 100 seed weight was found to be significantly and positively correlated with plant height, panicle breadth, panicle weight and fodder yield per plant. It was positively and significantly associated with grain yield in crosses M 35-1 × KMJ-1 and M 35-1 × AKJ-1. It was positively and significantly associated with panicle length in crosses M35-1 × RSJ-1 and M 35-1 × AKJ-1. In the cross M 35-1 × KMJ-1, 100 seed weight was found to be significantly and negatively correlated with popping expansion ratio. With days to 50% flowering, 100 seed weight was found to be significantly and negatively correlated in all the crosses except in M 35-1 x KMJ-1 which recorded non-significant association. Results of 100 seed weight showing non significant and positive correlation with grain yield per plant were obtained by Bakheti (1990) and Godbharle et al., (2010).

Flowering time

In the crosses M 35-1 × RSJ-1, M 35-1 × AKJ-1 and M 35-1 × SMJ-1 days to 50% flowering was found to be significantly and negatively correlated with panicle length, panicle breadth, panicle weight and 100 seed weight. In the crosses, M 35-1 × AKJ-1 and M 35-1 × SMJ-1, days to 50% flowering was found to be significantly and negatively correlated with fodder yield per plant. In the cross M 35-1 × KMJ-1, days to 50% flowering was found to be significantly and positively correlated with plant height. Whereas it was significantly negatively correlated with plant height in other crosses M 35-1 x RSJ-1 and M 35-1 x AKJ-1. Days to 50% flowering was significantly and positively correlated with grain yield per plant, were reported by Liang et al., (1969), Crook and Casady (1974), Sindagi et al., (1970), Patel et al., (1980b), Jadhav et al., (1994), Veerabadhiran et al., (2001), Prabhakar (2001), Rajkumar et al., (2007), and Seetharam and and Ganesamurthy (2013).

Popping quality traits

All the popping quality traits viz., popping yield (%), expansion ratio and flake size were positively significantly associated with panicle length in the cross M 35-1 x KMJ-1. Significant positive association was noticed between popping traits popping yield (%), expansion ratio and flake size. In a study by Mallinath et al., (2004), it was also reported that popping yield was positively correlated with the expansion ratio and flake size, and the positive correlation observed among flake size and expansion ratio. In the present study significant negative association was found between popping expansion ratio and 100 seed weight. In a study conducted by Jele et al., (2014) to determine relationships among quality traits in popcorn hybrids, it was also reported a significant negative relationship between flake volume and kernel size; while the number of unpopped kernels was positively correlated with kernel size (p≤0.05). In the present study popping yield and flake size were significantly positively associated with panicle weight and grain yield per plant. Panicle length was significantly and positively associated with panicle breadth, panicle weight, grain yield per plant and fodder yield per plant. Therefore, panicle length may be used as indirect selection criteria in isolating desired genotypes with high yield and popping traits.

M 35-1, a popular variety of Rabi sorghum, derived from landrace and occupies major area since more than five decades. The specialty varieties are derived from landraces that are evolved in the Rabi sorghum belt along with many relatives of Maldandi. It is challenging to isolate high yielding lines with specialty grain traits maintained in the crosses...
of M 35-1 with these specialty varieties. The association study indicated the scope for isolation of segregants with high yield and yield components in the crosses M 35-1 x AKJ-1 (flaking variety) and M 35-1 x KMJ-1 (popping variety) and early with high yield in the cross M 35-1 x AKJ-1. However, it needs to be studied the association of yield with flaking quality traits in M 35-1 x AKJ-1. The association of popping quality traits studied in the cross M 35-1 x KMJ-1 indicated the significant positive association of grain yield and panicle length with popping quality traits (popping yield, popping expansion ratio and flake size), significant positive association between panicle length, grain yield and fodder yield. Therefore, panicle length in this cross can be used as indirect selection criteria to isolate desired lines of pop sorghum. The significant negative association of 100 seed weight with popping expansion ration indicated that smaller the seed size the greater popping expansion ratio. Regarding hurda varieties SMJ-1 and RSJ-1, the non-significant association of grain yield with number of yield components, indicating less scope for isolating high yielding genotypes in the crosses M 35-1 x SMJ-1 and M 35-1 x RSJ-1.

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Some of these varieties were subjected for pure line selection and evaluation, tested for nutrition and suitability for various food products and were released for cultivation in northern dry zone of Karnataka (The Gazette of India, 2018).

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