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# Correlation and path analysis in parents and hybrids for resistance to sorghum shoot fly [*Atherigona soccata* (Rondani)]

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**SUMMARY**

Correlation, and path analysis were carried out in 20 parents and 87 hybrids of sorghum for 13 characters to assess the factors responsible for resistance to sorghum shoot fly both during rainy and post rainy seasons. Correlation trends and values were similar among parents and hybrids as well as during rainy and post rainy seasons. Egg count, per cent oviposition and deadheart percentage were strongly associated with each other. On the other hand, the defensive characters influenced each other and were positively interrelated. All the defensive characters were inversely related with susceptibility parameters like deadheart percentage, oviposition percentage and egg count. These defensive traits largely contribute to deadheart formation indirectly through per cent oviposition. Much contribution to deadheart percentage was through oviposition percentage and least from egg count. Hence, it is suggested to use per cent oviposition for indicating antixenosis type of resistance rather than egg count. An ideal ideotype must have high seedling vigour, narrow, erect, pale green leaves, high glossy character of leaves, dry central leaf whorl (leaf surface wetness), higher seedling and plant height, more number of trichomes on upper and lower leaves.

**Key words :** Correlation, Path analysis, Shoot fly, Resistance, Sorghum

The shoot fly, [*Atherigona soccata* Rondani (Diptera: Muscidae)] is one of the key pests of sorghum in sorghum growing areas of Asia, Europe and Africa. Up to 75.6 and 68.6 per cent losses by shoot fly in sorghum grain and fodder yield, respectively have been reported (Pawar *et al*., 1984). The resistance to sorghum shoot fly appears to be a complex character and depends upon the interplay of a number of component characters, which finally sum up on the expression of shoot fly resistance. In obtaining a clear picture of the contribution of each of such component character in building up the resistance, it would be necessary to discriminate them through their correlation and causation study involving these traits. Such a study would provide a realistic basis for allocation of weightage to each of the governing traits in deciding suitable selection criteria for genetic improvement of resistance. With this in view, an investigation was taken up, the results of which are presented in this paper.

## MATERIALS AND METHODS

Fourteen shoot fly resistant parents *viz*., ICSV 708, ICSV 714, IS 923, IS 2122, IS 2291, IS 2312, IS 2314, IS 5480, IS 5613, IS 5636, IS 22144, SPSFR 94012 A, SPSFR 94022 A and SPSFR 94031A and six susceptible parents but good for agronomic traits *viz*., RS 29, C 43, SB 7001, SB 401A, 2077A, and 27A were selected for the study, based on initial screening for resistance to shoot fly. Further, 84 hybrids obtained from crossing these parents in 14x6, L x T fashion were also included. Among these hybrids, 33 were cross between resistant x resistant, nine were between susceptible x susceptible, and 42 were between resistant x susceptible parents.

The 104 test entries including parents and hybrids were laid out in a randomised block design at Sorghum Research Scheme, University of Agricultural Sciences, Dharwad during both rainy and post rainy seasons. During each season, the seeds of entries were sown in a plot size of 1.8 x 4.5 m with inter and intra row spacing of 45 and 15 cm, respectively. Interlard Fishmeal Technique (Taneja and Leuschner, 1985) was adopted to ensure high and uniform pressure of shoot fly infestation on test entries. In this technique, susceptible entry CSH-1 was sown 14 days earlier to test material as interlards at every 24 rows. Fishmeal was kept in the field as to attract shoot fly, multiply them in susceptible entry, and then infest the test material uniformly. Observations were recorded on 8 components of resistance to shoot fly *viz*., seedling vigour, glossiness, leaf colour, leaf width, leaf erectness, seedling height, trichome density, leaf surface wetness; and three shoot fly damage indicating traits *viz*., egg load, per cent oviposition and deadheart percentage besides on plant height and yield. Observations on all the component traits

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of resistance were recorded at 14 days and on the traits indicating shoot fly infestation at 28 days after the emergence of the crop. Plant height and yield were recorded at harvest. Simple correlation coefficients were computed and tested for significance as per the procedure given by Panse and Sukhatme (1985). Path analysis developed by Wright (1921) and Dewey and Lu (1959) was used to find out direct and indirect effects.

## RESULTS AND DISCUSSION

The association between shoot fly resistance and its components computed in terms of phenotypic correlation coefficients among the parents and hybrids for 13 relevant variables in rainy and post rainy seasons are presented in Table1. In general, there were neither seasonal nor hybrid-parental differences regarding correlation between various characters of resistance to shoot fly. Formation of deadheart is an apparent and ultimate indicator for susceptibility to shoot fly. Shoot fly susceptibility is significantly and positively associated with egg load per plant and per cent oviposition. On the contrary, deadheart percentage was negatively correlated with seedling vigour, glossiness, light green colour of leaves, erect leaves, seedling height, trichome density and low leaf surface wetness during both seasons and within parents and hybrids. Per cent oviposition was strongly and positively correlated with deadheart formation in parents with high values of 0.93 and 0.92 during rainy and post rainy seasons, respectively. Similarly high correlation values of 0.88 and 0.92 were noticed for hybrids during rainy and post rainy seasons, respectively. Highly significant negative correlation coefficients were observed between per cent oviposition and other eight traits associated with resistance. Egg count, per cent oviposition and deadheart percentage were strongly associated with each other. This may be due to fact that high egg load is due to heavy shoot fly population which ensures availability of large number of shoot flies for oviposition, thereby ultimately leads to high deadheart percentage in the genotypes. Thus, these traits are interrelated and one influences the other. On the other hand, traits related to resistance like seedling vigour, glossiness, erect leaves, light green coloured leaves, narrow leaves, seedling height, trichome density and low leaf surface wetness were highly associated among themselves. Further, these two sets of characters *viz*., traits indicating the resistance and characters governing the resistance were inversely related to each other. These results are in agreement with the findings of Omori *et al*. (1983), Taneja and Leuschner (1985), Mate (1979), Maiti and Bidinger (1979), Bapat and Mote (1982), Jayanti (1997), and Kamatar and Salimath (2002).

The probable reasons for positive associations of resistance traits are: i) seedling vigour influences the seedling height (Biradar and Borikar, 1983); (ii) presence of smooth structure wax may make the leaves to appear shiny, glossy and pale yellowish green colour; (iii) narrow leaves stand erect than broad leaves; (iv) trichomeless cultivars of pearl millet accumulate more dew and leaf surface stays wet longer (Burton *et al*., 1977); and (v) smooth wax present on glossy leaves will not allow water droplets to spread on leaves (Nwanze *et al*., 1992). Because of these interrelationships, defensive characters showed highly positive correlations with each other. These types of association provide the breeder with a scope to go in for selection of only a few traits, which are most important and feasible to score while screening a large population.

Inverse association of defensive traits and susceptibility parameters of shoot fly may be due to: (i) rapid growth and tall seedlings may make it impossible for the freshly hatched larva to reach central whorl from third or fourth leaf (Mate *et al*., 1979); larva cannot survive if it does not reach the growing point early, because it feeds on only decayed material after cutting the growing tip; (ii) similarly, presence of trichomes on leaf surface injures the larva by their sharp points and makes the movement difficult towards growing tip; (iii) wet central whorl facilitate the movement of freshly hatched larva to the base of the central shoot and otherwise (Raina, 1981); (iv) glossy leaves may deter the shoot fly not to lay eggs on them; and (v) glossy and trichomed leaves allow less water droplets on themselves which affects the freshly hatched larval movement. All these factors ultimately reduce deadheart formation.

Grain yield was negatively correlated with plant height among parents, whereas it was positively correlated among hybrids. This may be due to low grain yielding ability of tall land races, which were resistant to shoot fly. Whereas, hybrids, in spite of being tall produced higher grain yield due to their hybrid vigour. Kumaravadivel and Amirthadevarathinam (2000) noticed significant negative correlation of grain yield with plant height in F2 generation.

Results of path analysis over rainy and post rainy seasons have been presented in Table 2. The low residual effect of 0.138 signifies appropriateness of chosen characters in representing the total variability of deadheart percentage. Plants with eggs (per cent oviposition) showed highest positive correlation of deadheart percentage. Path analysis revealed that this high correlation between these two traits was mainly due to high positive direct effect of per cent oviposition of 0.756 on deadheart percentage.

**Table 1 : Correlation coefficient values among various characters associated with resistance to sorghum shoot fly for parents and hybrids in *Kharif* and *Rabi* seasons**

| Sr. No. | Traits | | | 2 GI | 3 L.C. | 4 L.W | 5 L.D. | 6 S.H. | 7 T.D. | 8 LSW | 9 E.C | 10 PWE | 11 DH | 12 P.H. | 13 Yd. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Seedling vigour | P | K | 0.87** | 0.78** | 0.67** | 0.68** | -0.60** | -0.79** | 0.75** | 0.77** | 0.61** | 0.64** | -0.55** | 0.62** |
| | | | R | 0.72** | 0.68** | 0.50** | 0.57** | -0.63** | -0.64** | 0.61** | 0.79** | 0.38** | 0.56** | -0.56** | 0.72** |
| | | H | K | 0.67** | 0.60** | 0.40** | 0.49** | -0.45** | -0.46** | 0.39** | 0.18* | 0.44** | 0.48** | -0.18* | 0.10 |
| | | | R | 0.60** | 0.45** | 0.28** | 0.23** | -0.60** | -0.49** | 0.37** | 0.15* | 0.49** | 0.51** | -0.21* | -0.02 |
| 2. | Glossiness | P | K | | 0.91** | 0.85** | 0.80** | -0.62** | -0.85** | 0.82** | 0.83** | 0.75** | 0.76** | -0.52** | 0.79** |
| | | | R | | 0.91** | 0.81** | 0.80** | -0.36* | -0.85** | 0.87** | 0.80** | 0.56** | 0.70** | -0.48** | 0.80** |
| | | H | K | | 0.86** | 0.68** | 0.76** | -0.34** | -0.60** | 0.50** | 0.29** | 0.62** | 0.62** | -0.06 | 0.30** |
| | | | R | | 0.77** | 0.63** | 0.66** | -0.28** | -0.55** | 0.46** | 0.30** | 0.50** | 0.51** | -0.12 | 0.17* |
| 3. | Leaf colour | P | K | | | 0.83** | 0.81** | -0.56** | -0.81** | 0.74** | 0.73** | 0.71** | 0.69** | -0.44** | 0.79** |
| | | | R | | | 0.7** | 0.78** | -0.22 | -0.78** | 0.83** | 0.75** | 0.54** | 0.66** | -0.38* | 0.76** |
| | | H | K | | | 0.71** | 0.73** | -0.34** | -0.56** | 0.48** | 0.24** | 0.58** | 0.58** | -0.04 | 0.33** |
| | | | R | | | 0.62** | 0.62** | -0.19* | -0.51** | 0.44** | 0.28** | 0.45** | 0.49** | -0.02 | 0.23** |
| 4. | Leaf width | P | K | | | | 0.79** | -0.37* | -0.72** | 0.66** | 0.73** | 0.69** | 0.72** | -0.37* | 0.66** |
| | | | R | | | | 0.748** | -0.27 | -0.70** | 0.71** | 0.61** | 0.41** | 0.52** | -0.37* | 0.60** |
| | | H | K | | | | 0.748** | -0.17* | -0.36** | 0.45** | 0.11 | 0.46** | 0.47** | -0.06 | 0.31** |
| | | | R | | | | 0.76** | 0.02 | -0.28** | 0.31** | 0.13 | 0.31** | 0.31** | -0.02 | 0.27** |
| 5. | Leaf droopiness | P | K | | | | | -0.37* | -0.68** | 0.66** | 0.70** | 0.65** | 0.67** | -0.25 | 0.60** |
| | | | R | | | | | -0.17 | -0.63** | 0.66** | 0.69** | 0.54** | 0.62** | -0.18 | 0.62** |
| | | H | K | | | | | -0.15* | -0.45** | 0.47** | 0.12 | 0.53** | 0.53** | -0.01 | 0.24** |
| | | | R | | | | | -0.05 | -0.35** | 0.34** | 0.27** | 0.36** | 0.31** | -0.02 | 0.28** |
| 6. | Seedling height | P | K | | | | | | -0.53** | -0.51** | -0.60** | -0.53* | -0.43** | -0.33* | -0.62** |
| | | | R | | | | | | 0.33* | -0.29 | -0.46** | -0.80 | -0.20 | 0.37* | -0.31* |
| | | H | K | | | | | | 0.37** | -0.16* | -0.16* | -0.26** | -0.25** | 0.30** | -0.15* |
| | | | R | | | | | | 0.40** | -0.20** | -0.09 | -0.49** | -0.49** | 0.17* | -0.09 |
| 7. | Trichome density | P | K | | | | | | | -0.88** | -0.74** | -0.75** | -0.79** | 0.43** | -0.67** |
| | | | R | | | | | | | -0.89** | -0.76** | -0.58** | -0.72** | 0.50** | -0.78** |
| | | H | K | | | | | | | -0.57** | -0.42** | -0.67** | -0.75** | 0.06 | -0.21** |
| | | | R | | | | | | | -0.58** | -0.44** | -0.52** | -0.54** | 0.06 | -0.16* |
| 8. | Leaf surface wetness | P | K | | | | | | | | 0.76** | 0.75** | 0.79** | -0.34* | 0.62** |
| | | | R | | | | | | | | 0.76** | 0.64** | 0.79** | -0.35* | 0.72** |
| | | H | K | | | | | | | | 0.34** | 0.73** | 0.80** | -0.04 | 0.18* |
| | | | R | | | | | | | | 0.36** | 0.38** | 0.40** | -0.03 | 0.18* |
| 9. | Egg count | P | K | | | | | | | | | 0.81** | 0.78** | -0.37* | 0.63** |
| | | | R | | | | | | | | | 0.57** | 0.69** | -0.39** | 0.75** |
| | | H | K | | | | | | | | | 0.39** | 0.37** | 0.16* | 0.12 |
| | | | R | | | | | | | | | 0.29** | 0.27** | 0.09 | 0.17* |
| 10. | Plants with eggs | P | K | | | | | | | | | | 0.93** | -0.19 | 0.56** |
| | | | R | | | | | | | | | | 0.92** | -0.10 | 0.49** |
| | | H | K | | | | | | | | | | 0.88** | -0.01 | 0.24** |
| | | | R | | | | | | | | | | 0.92** | -0.06 | 0.02 |
| 11. | Dead hearts | P | K | | | | | | | | | | | -0.28 | 0.54** |
| | | | R | | | | | | | | | | | -0.20 | 0.65** |
| | | H | K | | | | | | | | | | | -0.02 | 0.25** |
| | | | R | | | | | | | | | | | -0.13 | 0.03 |
| 12. | Plant height | P | K | | | | | | | | | | | | -0.55** |
| | | | R | | | | | | | | | | | | -0.57** |
| | | H | K | | | | | | | | | | | | 0.39** |
| | | | R | | | | | | | | | | | | 0.40** |

* and ** indicate significance of values at P=0.05 and 0.01, respectively; P = Parent, H = Hybrid; K = *Kharif*; R = *Rabi*

**Table 2 : Path coefficient analysis showing direct and indirect effects of various traits associated with resistance to sorghum shoot fly in parents and hybrids over *Kharif* and *Rabi* seasons**

| Sr. No. | Traits | 1. S.V. | 2 GI | 3 L.C. | 4 L.W | 5 L.D. | 6 S.H. | 7 T.D. | 8 LSW | 9 E.C | 10 PWE | Corrl. with DH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Seedling vigour | 0.061 | -0.024 | 0.015 | 0.012 | -0.020 | 0.003 | 0.055 | 0.062 | -0.002 | 0.385 | 0.548 |
| 2. | Glossiness | 0.042 | -0.035 | 0.021 | 0.021 | -0.034 | 0.002 | 0.066 | 0.076 | -0.003 | 0.459 | 0.615 |
| 3. | Leaf colour | 0.036 | -0.030 | 0.025 | 0.021 | -0.033 | 0.001 | 0.062 | 0.072 | -0.002 | 0.429 | 0.581 |
| 4. | Leaf width | 0.024 | -0.024 | 0.017 | 0.030 | -0.037 | 0.00 | 0.041 | 0.057 | -0.001 | 0.316 | 0.423 |
| 5. | Leaf droopiness | 0.025 | -0.026 | 0.018 | 0.023 | -0.047 | 0.000 | 0.047 | 0.057 | -0.002 | 0.353 | 0.448 |
| 6. | Seedling height | -0.030 | 0.010 | -0.006 | -0.002 | 0.003 | -0.005 | -0.037 | -0.032 | 0.001 | -0.289 | -0.387 |
| 7. | Trichome density | -0.032 | 0.022 | -0.015 | -0.012 | 0.021 | -0.002 | -0.103 | -0.082 | 0.003 | -0.471 | -0.671 |
| 8. | Leaf surface wetness | 0.030 | -0.021 | 0.014 | 0.013 | -0.021 | 0.001 | 0.067 | 0.126 | -0.03 | 0.476 | 0.682 |
| 9. | Egg count | 0.021 | -0.015 | 0.010 | 0.007 | -0.013 | 0.001 | 0.053 | 0.067 | -0.006 | 0.369 | 0.476 |
| 10. | Plants with eggs | 0.031 | -0.021 | 0.014 | 0.013 | -0.022 | 0.002 | 0.064 | 0.079 | -0.002 | 0.756 | 0.914 |

Residual effect = 0.138
Bold figures indicate direct effects

Another trait egg count so far considered to be of equal importance in increasing the deadheart percentage, had correlation coefficient of only 0.476 compared to oviposition percentage and contributed as low as -0.006 for deadheart formation. Its significant correlation with deadheart formation was mainly through per cent oviposition (0.369) Thus data revealed that per cent oviposition is an important component in causing deadheart formation, because it had relatively large positive direct effect, which was near to its correlation value. This direct influence was reinforced by its indirect effect through high trichome density and high leaf surface wetness. The magnitude of direct effect of leaf surface wetness and trichome density were next to per cent oviposition and hence may be regarded as two important characters influencing deadheart percentage. However, their indirect contributions (0.476, and -0.471) through per cent oviposition were much more than their direct effects (0.126, and -0.103). These results support the findings of Maiti *et al*. (1980), Omori *et al*. (1983) and Karanjkar *et al*. (1992). Even though egg count had significant correlation with deadheart percentage, its direct contribution was very much negligible, whereas indirect contribution through per cent oviposition was much more. Kamatar and Salimath (2002) observed similar results in their study of 650 land races over two post rainy seasons Hence, it is suggested to use per cent of plants infested with shoot fly eggs rather than egg count to screen for shoot fly resistance.

All the defensive characters like seedling vigour, glossiness, leaf colour, leaf width, leaf droopiness, seedling height, trichome density and leaf surface wetness had contributed indirectly through per cent oviposition rather than their direct effects on deadheart percentage. Based on the path analysis, it may be concluded that all these defensive characters strongly influence the oviposition. Oviposition is apparent indicator of susceptibility to shoot fly as it had strong and direct influence on deadheart formation. Egg count as the selection criteria could be misleading in deciding resistance to shoot fly, as its direct effect on deadheart formation was negligible and it influenced only through per cent oviposition.

Following comprehensive conclusions may be drawn based on the studies of correlation and path analysis on 20 parents and 84 hybrids:

– Resistance to shoot fly is a complex phenomenon and is controlled by many defensive characters like seedling vigour, glossiness, light green leaf colour, erectness of leaf, seedling height, trichome density and leaf surface wetness.

– There may not be any gene for resistance to shoot fly in sorghum as such, but operate only through its defensive traits, as sorghum does not posses any key feature that endows it with resistance against shoot fly; hence, absolute resistance is not available in sorghum.

– The defensive characters are favourably interrelated to each other.

– All the defensive characters are inversely related with susceptibility parameters like deadheart percentage, oviposition percentage and egg count. These defensive traits largely contribute to deadheart formation indirectly through per cent oviposition.

– Much contribution to deadheart percentage comes from oviposition percentage and resistance rather than egg count.

Based on the results obtained from the present experiment, an ideal plant type with high productivity and resistance to shoot fly is suggested. An ideal ideotype must have high seedling vigour, narrow, erect, pale green leaves, high glossy leaves, dry central leaf whorl (leaf surface wetness), higher seedling and plant height, more number of trichomes on upper and lower leaves.

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