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Grouping of Disease Resistant Sorghum Genotypes Based on Cluster Analysis Multivariate Tool

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Sorghum ranks as the fifth leading cereal grain globally in terms of both production and cultivated area, following wheat, rice, maize, and barley. Disease incidence is a significant limiting factor for sorghum production, directly impacting crop yield. This study utilizes secondary data collected from the All India Co-ordinated Research Project (AICRP) on Sorghum, Dharwad Centre. A total of forty-four genotypes were assessed in Initial Advanced Hybrid Trials, and forty-three genotypes were evaluated in Varietal Trials to study disease incidence, specifically Downy mildew, Charcoal rot, and Rust. The disease scores obtained from all genotypes were subjected to Hierarchical Clustering analysis to cluster the genotypes based on their disease resistance. The clustering

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analysis, using between-group linkage and dendrogram construction, resulted in the division of the forty-four hybrids into two clusters, while the forty-three varieties were grouped into three clusters. Notably, CSV 22 and CSV 29 R demonstrated high resistance to charcoal rot and resistance to both downy mildew and rust. On the other hand, SPV2758 and SPV2746 exhibited high susceptibility to downy mildew, resistance to rust, and moderate resistance to charcoal rot. The identified genotypes in this study hold potential as valuable sources of multiple disease resistance for incorporation into breeding programs aimed at varietal or hybrid development.

Keywords: Cluster; dendrogram; hierarchical clustering; disease scores; genotypes.

1. INTRODUCTION

Sorghum bicolor (L.) Moench is an important cereal crop grown worldwide for its grains, forage, and as a bioenergy feedstock. It belongs to the *Poaceae* family and is known for its resilience and adaptability to a wide range of agroecological conditions, including drought-prone and semi-arid regions [1]. Sorghum is the fifth leading cereal grain worldwide after wheat, rice, maize and barley in terms of production with a cultivated area of about 40.92 m ha (Million hectares) and total production of 61.36 MMT (Million metric tons) [2]. Sorghum grains are a valuable source of nutrition, rich in carbohydrates, protein, dietary fiber, and minerals. They are utilized for human consumption in various forms such as flour, porridge, and traditional dishes. Additionally, sorghum grains are used for animal feed due to their high nutrient content and digestibility. With its ability to adapt to diverse agroclimatic conditions and exhibit tolerance to drought and heat stress, sorghum plays a crucial role in food security, livestock feed, and industrial applications [3]. Additionally, sorghum is used in the production of biofuels, such as ethanol, due to its high content of fermentable sugars. Its stalks and residues can be processed into biofuels, particularly bioethanol, contributing to renewable energy sources and reducing greenhouse gas emissions [4].

Sorghum, commonly known as 'Jowar', is one of India's most important millets. In India, it is cultivated on 3.84 million hectares (ha), with a production and productivity of 3.76 million tons (mt) and 979 kg/ha respectively [5]. The major sorghum-cultivating states in India are Maharashtra, Karnataka, Rajasthan, Tamil Nadu, and Andhra Pradesh. It is grown in two seasons: the kharif season as a rainfed crop and the rabi season under remaining soil moisture conditions. In Karnataka, sorghum is cultivated on 1.09 million hectares, with 0.116 million hectares in *kharif* and 0.974 million hectares in *rabi*, resulting in a production and productivity of 1.15 million tons and 1,052 kg/ha respectively [6]. The major sorghum-cultivating regions in Karnataka include Kalburgi, Vijayapura, Belagavi, Gadag, Bagalkote, and Raichur.

Charcoal rot, caused by *Macrophomina phaseolina* (Tassi.) Goid, is a major disease among the biotic stresses affecting crops during the post-rainy season. It leads to significant losses in both grain and fodder yield Fig. 1. In India, almost all cultivated hybrids and varieties are susceptible to charcoal rot [7]. The disease is characterized by poor grain filling, premature leaf senescence, and crop lodging. Internally, the stem pith of infected plants becomes disintegrated and the separated, fibro vascular bundles are covered with the small black sclerotial bodies of the fungus which give the stem a blackened appearance, hence the name "charcoal rot" [8].

The sorghum crop is hampered by several biotic stresses, one of the most devastating diseases is downy mildew. The disease is caused by a soil-borne *Peronosclerospora sorghi* fungus but, it is also transmitted through air borne conidia or sporangia. It is characterized by the appearance of yellow to tan lesions on leaves Fig. 2, which are later covered with a downy growth of the pathogen. The disease can lead to severe yield losses in sorghum production, making it an important concern for farmers and researchers [9].

Rust is caused by *Puccinia purpurea Cooke*. The symptoms are usually observed in plants aged 1 to 1.5 months. Minute flecks of different color (purple, tan or red) first appear on lower leaves Fig. 3. In resistant varieties the symptoms develop no further. In susceptible ones, as they fill with spores, the flecks turn into powdery, purplish, slightly raised pustules, circular to elongated in shape. They are loosely scattered or in patches and may darken even further as the plant matures. Leaf rust can cause significant yield losses in sorghum production, affecting both grain quality and quantity [10].

Cluster analysis is the important Multivariate tool which is mainly used for grouping [11]. Cluster analysis is applied to group the varieties grown in Hybrid trials which are resistant to major Rabi diseases like charcoal rot, rust and downy mildew. And further to make an appropriate selection of resistant source. [12] Verma et al. (2018) studied on qualitative phytochemical and cluster analysis of genotypic extract of coriander leaves and seeds from Tarai and Kumaun regions of Uttarakhand and Himalayan state of India. The Phyto constituents in various genotypes were analysed using software The Unscramble * 10.5 and applied Ward's method with squared euclidean distance using dendogram genotypes were grouped into five clusters. This paper focuses on selection of disease resistant Sorghum genotypes for agricultural purpose.

2. MATERIALS AND METHODS

The study is based on the secondary data collected on disease incidence of Downy mildew, Charcoal rot and Rust from Forty-four genotypes which were grown in Initial advanced hybrid trials and forty-three genotypes which were grown in Varietal trial in All India Co-ordinated Research Project (AICRP) on Sorghum, Dharwad Centre. In the present study Cluster analysis is done in an attempt to combine cases into groups. Hierarchical Clustering method based on squared Euclidian distance was done by using statistical software SPSS16.

3. RESULTS AND DISCUSSION

Hierarchical cluster analysis was used to group the genotypes which are grown in advance varietal trials and advanced hybrid trials in the year 2019. Distances were calculated based on squared Euclidean distance by Agglomeration method.

3.1 Clustering of Genotypes Grown in Advanced Hybrid Trials

Grouping of 44 genotypes, which are grown in advanced hybrid trials based on the scores of major disease like, charcoal rot, downy mildew percentage, and rust. The genotypes classified into two clusters each containing 26 and 18 genotypes respectively which are presented in Table 1. For downy mildew disease the mean performance of the clusters were 20 and 9 respectively. It indicates that cluster I was susceptible and cluster II is moderately resistant. Similarly, for rust the mean performance of clusters were 2.9 and 3 which shows all genotypes were resistant respectively. The mean performance of the clusters was given in Table 2.

Among 18 genotypes in cluster II, eight genotypes like CSV 22, CSV 29 R (Deep soil), SPH 1897, CSV 29R, SPV 2468, SPV 2640, SPV 2644, SPV 2649 and M 35-1 shows the multiple disease resistance. In these 8 genotypes CSV 22 and CSV 29 R can be used as multiple disease resistant source in breeding programmes for varietal/ hybrid development as they are highly resistant to charcoal rot and resistant to both downy mildew and rust. The similarity between these two genotypes was more because of less distance between them (*i.e.,* 3.576). and the dendogram of cluster analysis is presented in Fig. 4.

The present study was supported by Umamaheshwari [13] who used Tocher's method of hierarchal cluster analysis for grouping of 41 sorghum genotypes based on 11 quantitative characters to study the genetic differentiation of landraces and varieties through morphological and molecular markers.

Table 1. Clusters of genotypes in Initial advanced hybrid trial (IAHT)

	No. of genotypes	Genotypes
Cluster I	26	SPH1903, SPV2653, SPV2654, SPV2655, SPV2658, SPV2660, CSH 13, CSH 15R, M35-1, Phule Anurada, SPH1869, SPH1931, SPV2635, SPV2636, SPV2639, SPV2641, SPV2642, SPV2643, SPV2647, SPV2648, CSH 15R, SPV2656, CSV26, Phule Maule, CSH13, SPV2747.
Cluster II	18	SPV2562, SPV2657, SPV2659, SPV2661, SPV2662, CSV 29R, E36-1, SPH1897, SPV2468, SPV2638, SPV2640, SPV2644, SPV2645, SPV264, SPV2649, CSV 22, CSV 29R, M35-1.

3.2 Clustering of Genotypes Grown in Initial Varietal Trials (IVT)

On the basis of cluster analysis, 43 genotypes were grouped into three clusters (Table 3) Maximum number of genotypes was grouped into cluster II (*i,e.* 32 genotypes) and cluster I and cluster III contains 9 and 2 genotypes.

In IVT 43 genotypes were grown in the year 2019 which were grouped into three clusters. Cluster I contain genotypes which are resistant and moderately resistant to both charcoal rot and rust but Susceptible to downy mildew.

Cluster II contains more genotypes which were moderately resistant to charcoal rot, resistant to rust and susceptible to downy mildew. Whereas, Cluster III had genotypes which were highly susceptible to downy mildew, resistant to rust and moderately resistant to charcoal rot. The dendrogram is presented in Fig. 5.

Fig. 1. Charcoal rot discoloration of vascular bundles

Table 2. Cluster means of genotypes

	Charcoal rot index	Downy mildew	Rust
Cluster I	15	20	2.9
Cluster II	14	9	3

Fig. 2. Downey mildew: Downey growth of fungus corresponding chlorotic streaks on upper surface

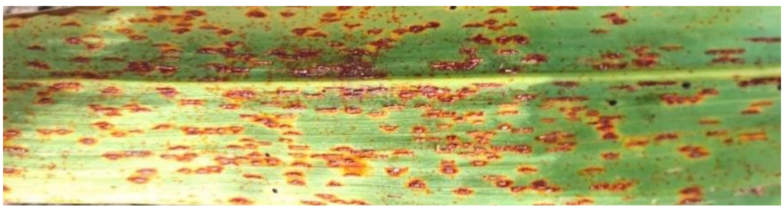

Fig. 3. Rust postules on the surface of the leaf

Table 3. Clusters of genotypes in Initial varietal Trial (IVT)

	No. of genotypes	Genotypes
Cluster I	9	SPV2748, SPV2756, SPV2760, CSH13, Phule Maule, CSV13, SPV2740, SPV2741, SPV2745.
Cluster II	32	SPV2749, SPV2750, SPV2751, SPV2752, SPV2753, SPV2754, SPV2755, SPV2757, SPV2759, CSH 15R, CSH 39R, CSV 26, Phule Anuradha, SPH1963, SPH1964, SPH1965, SPV2732, SPV2733, SPV2734, SPV2735, SPV2736, SPV2737, SPV2738, SPV2739, SPV2742, SPV2743, SPV2744, CSH 13, CSH 15R, CSH 39R, CSV 22, CSV 29R
Cluster III	2	SPV2758, SPV2746.

Table 4. Cluster means of genotypes

	Charcoal rot index	Downy mildew	Rust
Cluster I	10	15	3
Cluster II	16	22	3
Cluster III	22	33	3

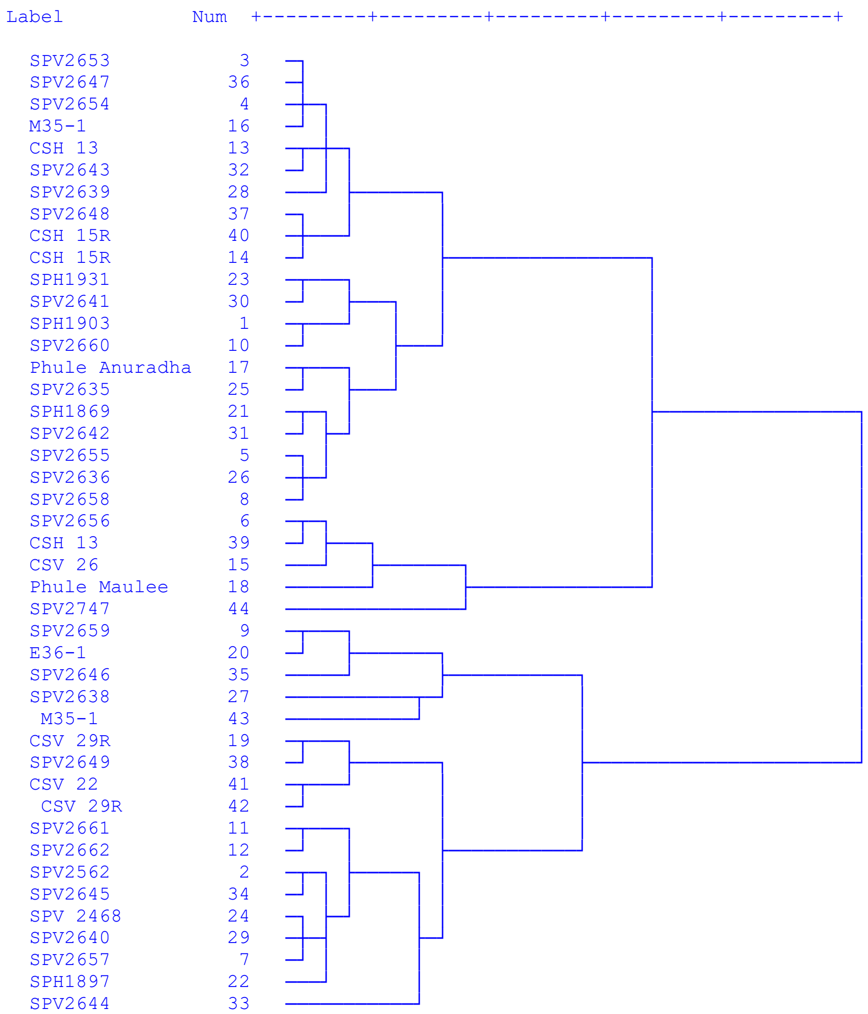

Fig. 4. Dendrogram using average linkage (between groups) for genotypes of IAHT

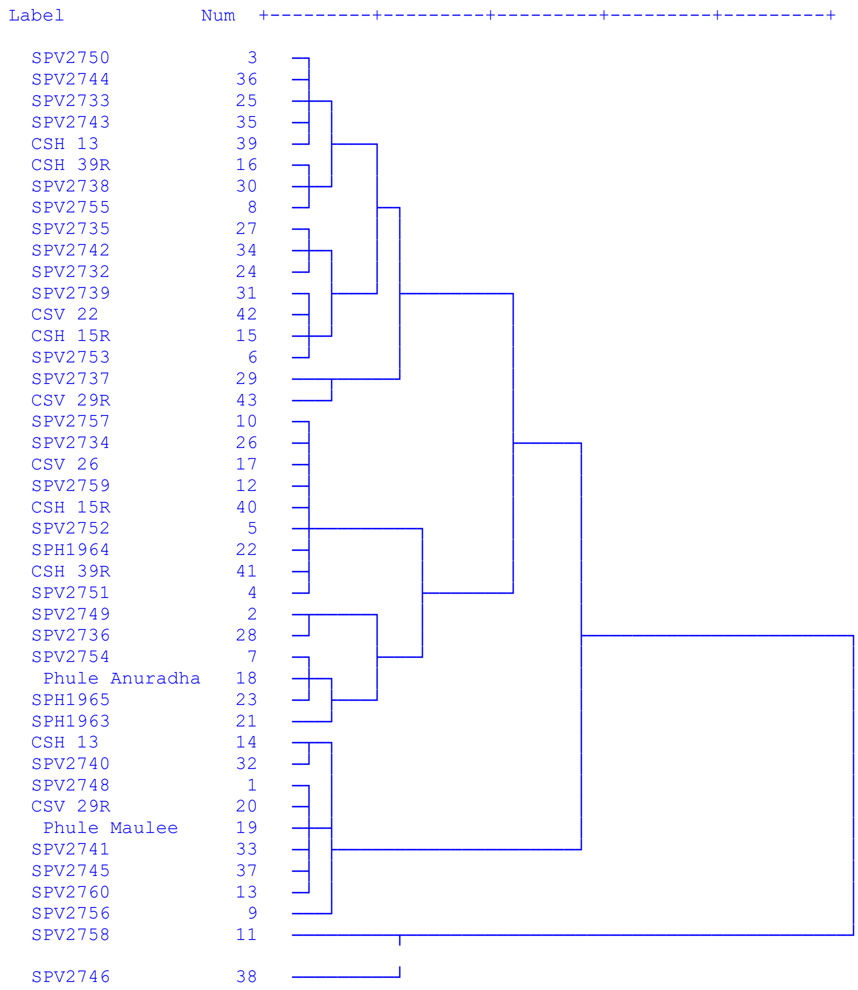

Fig. 5. Dendrogram using average linkage (between groups) for genotypes of IVT

4. CONCLUSION

In the conclusion we can say that the identified genotypes by using the multivariate tool in this study hold potential as valuable sources of multiple disease resistance for incorporation into breeding programs aimed at varietal or hybrid development.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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