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TRAIT INTERRELATIONSHIPS AND ITS CONTRIBUTION TO GRAIN YIELD: A CASE STUDY IN F_2 GENERATIONS DERIVED USING PARTIAL MALE STERILE LINES OF FINGER MILLET (*ELEUSINE CORACANA*)

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ABSTRACT

The present study was conducted to investigate the association between grain yield and its contributing traits in finger millet (*Eleusine coracana*) at the AICRP on Small Millets, Zonal Agricultural Research Station, University of Agricultural Sciences, Bangalore. Three F_2 populations derived from the crosses E-13-2 × GE4972, 21-8-4 × GE4972, and 21-8-4 × GE1409 were evaluated for correlation analysis. Observations were recorded on seven agronomic traits *viz.*, plant height, number of productive tillers, finger length, finger number, ear head weight, grain yield per plant and threshing percentage. Among these, ear head weight exhibited a strong, positive and statistically significant correlation with grain yield across all crosses indicating its potential as a primary selection criterion. Additionally, number of productive tillers, finger number, and threshing percentage also showed positive associations with yield suggesting their relevance as secondary yield-contributing traits. In contrast, plant height showed a negative correlation with number of productive tillers, and finger length was negatively correlated with threshing percentage. These findings underscore the utility of ear head weight and productive tiller number as reliable surrogate traits for the selection of high-yielding genotypes in finger millet breeding programs

Keywords: Finger millet (*Eleusine coracana*), plant height, number of productive tillers, finger length, finger number, ear head weight, grain yield per plant , threshing percentage

Introduction

Eleusine coracana (L.) Gaertn., commonly known as finger millet, belongs to the order *Poales*, family *Poaceae*, and subfamily *Chloridoideae*. The wild species *Eleusine africana* is regarded as its progenitor (Chennaveeraiah and Hiremath, 1974; Hilu and de Wet, 1976). East Africa considered as the primary centre of origin (de Wet, 1995). Finger millet is an allotetraploid species (2n = 4x = 36) and is predominantly self-pollinated. It is a climate-resilient cereal crop cultivated mainly in arid and semi-arid regions of Asia and Africa. It holds significant promise for ensuring food and nutritional security, especially in marginal environments due to its exceptional tolerance to drought, minimal input requirements and high nutritional value particularly its calcium, fibre, and micronutrient content.

Improving grain yield in finger millet remains a major objective in breeding programs. However, yield is a complex quantitative trait influenced by a multitude of morphological, physiological, and genetic factors each interacting in intricate ways. Direct selection for yield alone is often inefficient due to its low heritability and high sensitivity to environmental conditions. Moreover, the complex and integrated structure of the plant, where most traits are interrelated and governed by multiple genes further complicates the selection process. This necessitates a comprehensive understanding of the nature and strength of associations between yield and its contributing traits as well as the extent of genetic variability within the population. Therefore, the present investigation was undertaken to assess the relative contribution of various yield components to grain yield and to examine their interrelationships through correlation analysis

Correlation analysis is a fundamental statistical tool widely used in plant breeding to assess the degree and direction of association between yield and its component traits. Understanding these interrelationships enables breeders to identify and prioritize secondary traits that are genetically linked to yield. Traits with strong and consistent positive correlations with grain yield can serve as effective indirect selection criteria. In finger millet, previous studies have reported significant correlations between grain yield and traits such as plant height, number of productive tillers, finger length, ear head weight, and thousand grain weight (Dhami *et al*., 2018; Owere *et al*., 2015, Andualem and Tadesse, 2011). By analysing the correlation among agronomic traits, breeders can gain valuable insights into the structure of trait relationships, facilitating more targeted and efficient selection for high-yielding genotypes.

Material and Method

The experimental material comprised F_2 populations derived from three cross combinations *viz.,* E-13-2 × GE4972, 21-8-4 × GE4972, and 21-8-4 × GE1409 consisting of 300, 188 and 228 individual F_2 plants, respectively. The crosses were developed by utilizing partial male sterile lines (PS lines: E-13-2 and 21-8-4) as female parent which makes crossing and identification of true F_1 easier (Nagaraja *et al*., 2023). The PS lines were derived by crossing PS 1 line to different genotypes having different genetic background (Manjappa, 2017). Further a virescence seedling marker was incorporated into PS lines through program which made hybridization easier in finger millet (Manjappa *et al*., 2024; Manjappa 2022). The F_2 populations, along with their respective parents were evaluated during the *Kharif* 2023 season at the experimental plots of the All India Coordinated Research Project (AICRP) on Small Millets, Zonal Agricultural Research Station (ZARS), University of Agricultural Sciences (UAS), Bangalore.

The F_2 plants were planted in rows of 3 m length, following a standard spacing of 30 × 10 cm. All recommended agronomic practices were adopted to ensure the optimal growth of the crop. Observations were recorded on individual F_2 plants for the following quantitative traits *viz.,* plant height (PH) in cm, number of productive tillers (PT), finger length (FL) in cm, finger number (FN), ear head weight (EHW) in grams, grain yield per plant (YLD) in grams and threshing percentage (TP). The correlation coefficients among the traits under investigation were estimated using the statistical procedures outlined by Panse and Sukhatme (1967). The analysis was done in R software ver. 4.3.3 using 'metan' package.

Results and Discussion

Understanding the interrelationship among agronomic traits is crucial for effective selection and genetic improvement in finger millet. In the present study, phenotypic correlation coefficients were estimated using the formula proposed by Panse and Sukhatme (1967) to assess the degree and direction of association between grain yield and its component traits. This analysis helps to identify traits that are positively or negatively associated with yield, thereby aiding in the selection of desirable genotypes. A positive and significant correlation indicates a mutual or complementary relationship between traits, while a negative correlation may reflect competition or trade-offs among them. The results obtained provide valuable information for formulating selection strategies in finger millet breeding programs.

The correlation coefficients among grain yield and its component traits in the finger millet cross E-13-2 × GE4972, 21-8-4 × GE4972, 21-8-4 × GE1409 are presented in Table 1, 2 and 3, respectively. The results revealed several significant associations, providing valuable insights for trait-based selection in yield improvement programs.

Ear head weight consistently exhibited the strongest and most significant positive correlation with grain yield across all three crosses: E-13-2 × GE4972 (r = 0.95, Table 1), 21-8-4 × GE4972 (r = 0.97, Table 2), 21-8-4 × GE1409 (r = 0.96, Table 3). This stable and strong association indicates that EHW is a key determinant of yield and should be prioritized in selection programs. Number of productive tillers also showed a significant positive correlation with grain yield across the crosses, E-13-2 × GE4972 (r = 0.40), 21-8-4 × GE4972 (r = 0.68), 21-8-4 × GE1409: (r = 0.59). This trend confirms that an increase in tillering ability positively influences yield, especially in the second and third crosses (Fig 1, 2 and 3). The results were in consonance with that of Madhavilatha *et al.* (2021), Chavan *et al.* (2020) Owere *et al.* (2015), Andualem and Tadesse (2011).A moderate but statistically significant positive correlation was observed between finger number and grain yield across all the studied crosses, including E-13-2 × GE4972 (r = 0.19), 21-8-4 × GE4972 (r = 0.28), and 21-8-4 × GE1409 (r = 0.28) Madhavilatha *et al*. (2021), Dhami *et al*. (2018), Owere *et al*. (2015). These results indicate that finger number may play a contributory role in improving grain yield and can be considered a supplementary selection criterion in breeding programs aimed at yield enhancement (Table 1, 2 and 3). Chavan *et al.* (2020) reported comparable findings in finger millet. Threshing percentage exhibited moderate and statistically significant positive correlations with grain yield across all the crosses evaluated *i.e.,* E-13-2 × GE4972 (r = 0.55), 21-8-4 × GE4972 (r = 0.31), and 21-8-4 × GE1409 (r = 0.52). These findings highlight the role of threshing percentage in contributing to grain yield per plant, suggesting its utility as a key indirect selection trait in breeding programs focused on yield improvement (Figure 1, 2 and 3). The results are supported by Eric *et al*. (2016). Plant height (PH) and flag leaf length (FL) showed weak and mostly non-significant correlations with yield except for FL in cross E-13-2 × GE4972, indicating that they are not major contributors to grain yield in the studied genotypes (Table 2 and 3). The results were contradictory to Andualem and Tadesse, (2011), Dhami *et al*. (2018), Owere *et al*. (2015).

Negative correlation was observed for productive tillers, grain yield, finger number with plant height which suggests that increase in plant height decreases the number of productive tillers and grain yield and vice versa. Also finger length showed a negative association with threshing percentage. Negative association between finger length and threshing percentage suggests that longer fingers may impede efficient grain separation during threshing (Figure 1, 2 and 3). This could be attributed to denser spikelet arrangement or stronger rachis structures in longer fingers, which may increase grain retention and reduce threshing efficiency. Additionally, non-uniform grain maturity along elongated fingers may further contribute to lower TP. Such structural and physiological trade-offs imply that while longer fingers may appear agronomically advantageous but they may compromise post-harvest processing. Therefore, breeding programs should aim to balance finger length with threshing efficiency to ensure both yield potential and ease of grain recovery. Similar results were observed by Gupta et al (1992) while evaluating 22 finger millet germplasm accessions.

Inter trait association was observed among few traits. Strong and significant positive correlations were observed among number of productive tillers, finger number and ear head weight across all the crosses indicating potential interdependence among these traits. In particular, the correlation between PT and EHW was notably strong in E-13-2 × GE4972 (r = 0.45), 21-8-4 × GE4972 (r = 0.73), and 21-8-4 × GE1409 (r = 0.60). Similar observations were also reported by Chavan *et al*. (2020) in finger millet. These associations suggest that selection for higher tillering may concurrently enhance ear head development and consequently, grain yield. Thus, genotypes exhibiting a combination of high tillering capacity, heavier ear heads and sufficient grain weight are promising candidates for yield-oriented breeding efforts.

Conclusion

Among all the traits evaluated, ear head weight consistently exhibited the strongest and most reliable association with grain yield across all genetic backgrounds, underscoring its significance as a primary selection criterion. In addition, number of productive tillers, finger number and threshing percentage demonstrated considerable potential as secondary traits contributing to yield improvement. The strong positive correlations among these traits and yield reinforce their importance in breeding strategies aimed at improving finger millet productivity.

Table 1: Estimates of correlation coefficients between yield and its contributing in finger millet cross E-13-2 × GE4972

	PH	**PT**	**FL**	**FN**	**EHW**	**YLD**	**TP**
PH	**1**						
PT	-0.05	**1**					
FL	0.17***	0.078	**1**				
FN	0.11	-0.05	0.28***	**1**			
EHW	0.04	0.45***	0.14*	0.18**	**1**		
YLD	0.09	0.40***	0.12*	0.19***	0.95***	**1**	
TP	0.13*	0.04	-0.01	0.14*	0.33***	0.55***	**1**

Table 2: Estimates of correlation coefficients between yield and its contributing in finger millet cross 21-8-4 × GE4972

	PH	PT	FL	FN	EHW	YLD	TP
PH	1						
PT	-0.26***	1					
FL	0.15*	0.01	1				
FN	0.04	0.12	0.24**	1			
EHW	-0.10	0.73***	0.09	0.31***	1		
YLD	-0.07	0.68***	0.06	0.28***	0.97***	1	
TP	0.10	0.01	-0.12	0.01	0.10	0.31***	1

Table 3: Estimates of correlation coefficients between yield and its contributing in finger millet cross 21-8-4 × GE1409

	PH	PT	FL	FN	EHW	YLD	TP
PH	1						
PT	0.02	1					
FL	-0.06	0.01	1				
FN	-0.20**	-0.01	0.23***	1			
EHW	0.03	0.60***	0.07	0.27***	1		
YLD	0.05	0.59***	0.05	0.28***	0.96***	1	
TP	0.14*	0.16*	-0.15*	0.14*	0.34***	0.52***	1

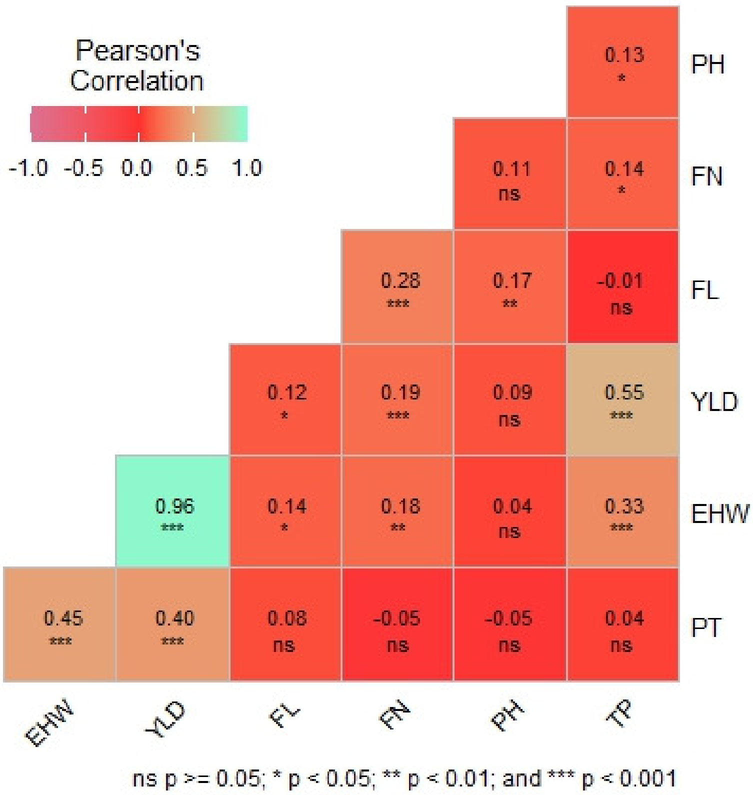

Fig. 1: Heat map of correlation coefficients between yield and its contributing in finger millet cross E-13-2 × GE4972

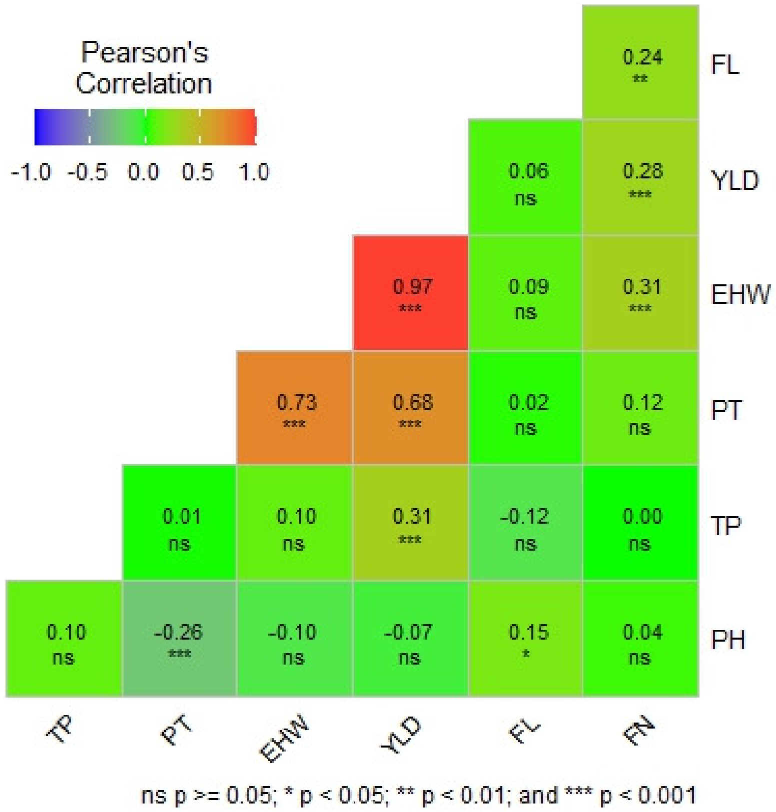

Fig. 2: Heat map of correlation coefficients between yield and its contributing in finger millet cross 21-8-4 × GE4972

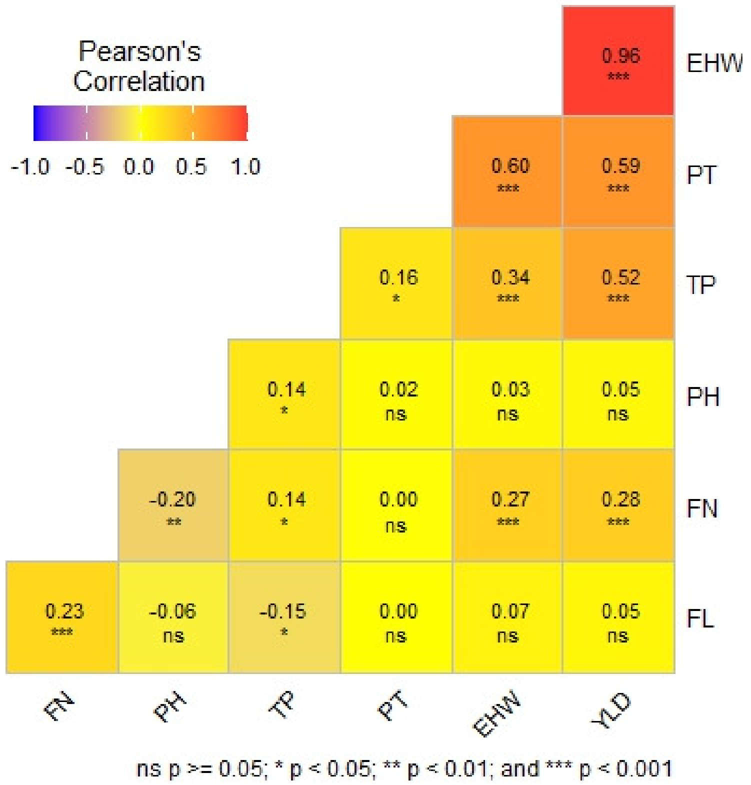

Fig. 3: Heat map of correlation coefficients between yield and its contributing in finger millet cross 21-8-4 × GE1409

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