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B Nagendra Naidu
P.G. Scholar, Department of Genetics and Plant Breeding, S.V. Agricultural College, Tirupati, Andhra Pradesh, India

M Hemanth Kumar
Principal Scientist and Head (Millets), Department of Genetics and Plant Breeding, ARS, Perumallapalle, Tirupati, Andhra Pradesh, India

M Reddi Sekhar
Professor, Department of Genetics and Plant Breeding, S.V. Agricultural College, Tirupati, Andhra Pradesh, India

AR Nirmal Kumar
Assistant Professor, Department of Crop Physiology, IFT, RARS, Tirupati, Andhra Pradesh, India

L Madhavi Latha
Scientist, Department of Genetics and Plant Breeding, ARS, Perumallapalle, Tirupati, Andhra Pradesh, India

Corresponding Author:
B Nagendra Naidu
P.G. Scholar, Department of Genetics and Plant Breeding, S.V. Agricultural College, Tirupati, Andhra Pradesh, India

Character association analysis for morphological and physiological characters in little millet (*Panicum sumatrense* Roth. ex Roem and Schult)

B Nagendra Naidu, M Hemanth Kumar, M Reddi Sekhar, AR Nirmal Kumar and L Madhavi Latha

Abstract
Correlation and path analysis were studied in a total of 20 crosses and nine parents (4 lines and 5 testers) by using line × tester analysis for 12 quantitative characters during *kharif* 2019. Observations recorded for main panicle weight (g) followed by fodder yield per plant, plant height, SPAD chlorophyll meter reading, harvest index and days to maturity showed strong, significant and positive association with grain yield per plant at both phenotypic and genotypic levels. Yield improvement could be possible through indirect selection for these traits to select high yielding genotypes in little millet. Fodder yield per plant followed by harvest index, main panicle weight, SPAD chlorophyll meter reading, specific leaf area, number of productive tillers per plant, panicle length and Days to 50% flowering showed maximum positive direct effect on grain yield per plant indicating the true relationship between these traits with grain yield per plant. Hence, direct selection for these traits would be rewarding for improvement of grain yield in little millet.

Keywords: Correlation, grain yield, little millet and path analysis

Introduction
Among millets, little millet (*Panicum sumatrense*) one of the most important small millets crop popularly known as 'sama', samo, vari, or kutki, belongs to the family Poaceae and sub family Panicoideae. It is a self-pollinated crop, having basic chromosome number 9 (tetraploid; 2n = 4x =36). The crop is widely cultivated across India, China, Sri Lanka, Nepal and Western Myanmar. In India, little millet is cultivated in Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Odisha, Bihar, Madhya Pradesh, Uttar Pradesh, Jharkhand, Chhattisgarh and Gujarat states.

Little millet accessions have been classified into 2 races based on panicle morphology, nana and robusta, with two sub races per race (laxa and erecta for nana, and laxa and compacta for robusta). It is fast growing early maturity crop resistant to adverse agro climatic conditions.

Little millet is well known for drought tolerance and considered as one of the least water demanding crop. In India little millet is cultivated in an area of 2.34 Lakh hectares with annual production of 1.27 Lakh tonnes and productivity of 544 Kg ha^{-1} (Anonymous, 2019). In Andhra Pradesh little millet is grown in an area of 7000 ha with production of 3000 t and productivity of 449 Kg ha^{-1} (Anonymous, 2019).

Estimation of correlation coefficients mostly indicate the inter relationships of the characters which is useful to plant breeder for selecting elite genotypes based on major contributing yield traits. Path analysis reveals whether the association of characters with yield is due to their direct effect on yield or is a consequence of their indirect effects *via* other component association of traits. Both correlation and path coefficient analysis was helpful for selection of suitable parents with high grain yield. Hence an effort was made to understand characters association with grain yield for enhancing productivity in little millet.

Materials and Methods
The present investigation was undertaken at Agricultural Research Station, Perumallapalle during *kharif*, 2019. The experimental material consisted of a total of 20 crosses and nine parents (4 lines and 5 testers) obtained by line × tester mating. Observations were recorded on five randomly selected plants from each replication for quantitative traits *viz.*, days to 50% flowering, days to maturity, plant height (cm), number of productive tillers per plant, panicle

length (cm), main panicle weight per plant (g), 1000 seed weight (g), grain yield per plant (kg), fodder yield per plant (kg) and physiological traits *viz.*, SCMR, specific leaf weight and harvest index (%). The data were subjected to statistical analysis and estimates of genotypic and phenotypic correlation coefficients were derived as per Johnson *et al.* (1955) [6] and estimates of direct and indirect effects of yield components as per Dewey and Lu (1959) [5].

Results and Discussions

Correlation analysis

ANOVA revealed highly significant differences among nine parents and twenty crosses of little millet indicating sufficient amount of variability. In general genotypic correlations were higher than the phenotypic correlations indicating the association is largely due to genetic reasons. In this study, genotypic correlations were higher than the phenotypic correlations which indicated the presence of inherent association among various traits.

The estimates among different pairs of characters at phenotypic and genotypic correlation are presented in Table.1and 2 respectively. A very strong significant positive association of main panicle weight per plant (0.798) followed by fodder yield per plant (0.637), plant height (0.544), SCMR (0.350), days to maturity (0.328) and harvest index (0.333) with grain yield per plant was observed at phenotypic level. Similar significant positive association of grain yield was earlier reported by Nirmalakumari *et al.* (2010) and Selvi *et al.* (2014) for plant height and Sasamala *et al.* (2015) and Nagar (2015) for harvest index in little millet. This suggests that selecting for the characters with high positive correlation would improve the grain yield in little millet.

Characters showed significant positive inter correlations among themselves Days to 50% flowering showed significant positive association with days to maturity. Days to maturity showed significant positive association with main panicle weight per plant and harvest index. Plant height showed significant positive association with panicle length, main panicle weight per plant, fodder yield per plant and SPAD chlorophyll meter reading. Number of productive tillers per plant showed significant positive association with panicle length. Main panicle weight per plant showed significant positive correlation with fodder yield per plant, harvest index and SPAD chlorophyll meter reading. Fodder yield per plant had significant positive association with specific leaf area indicating yield improvement could be possible through the indirect selection for these traits to select high yielding genotypes in little millet.

Table 1: Phenotypic (r_p) correlation coefficients among 12 quantitative characters in little millet traits in parents of little millet

	DM	PH	NPT	PL	MPW	1000SW	FY	HI	SCMR	SLA	GY
DFF	0.915**	-0.033	-0.043	-0.144	0.249	-0.254	-0.007	0.360**	-0.192	0.176	0.258
DM		0.054	-0.012	-0.099	0.326*	-0.292*	0.071	0.341**	-0.135	0.198	0.328*
PH			0.168	0.470**	0.491**	-0.120	0.722**	-0.268*	0.353**	0.135	0.544**
NPT				0.298*	-0.117	0.029	0.336**	-0.106	0.044	0.036	0.243
PL					-0.019	-0.035	0.231	-0.140	0.115	-0.106	0.138
MPW						-0.089	0.481**	0.260*	0.313*	0.111	0.798**
1000 SW							-0.042	0.107	-0.165	-0.340**	-0.041
FY								-0.468**	0.224	0.283*	0.637**
HI									-0.001	-0.324*	0.333*
SCMR										0.171	0.350**
SLA											0.112

* Significant at 5% level; ** Significant at 1% level

DFF: Days to 50% flowering; DM: Days to maturity; PH: Plant height(cm); NPT: Number of Productive tillers per plant; PL: Panicle length (cm); MPW: Main panicle weight per plant (g); 1000SW: 1000 Seed weight (g); FY: Fodder yield per plant (g); HI: Harvest index (%); SCMR:SPAD Chlorophyll meter reading; SLA: Specific leaf area (cm^2/g); GY: Grain yield per plant (g).

Path analysis

Path coefficient analysis is simply a standardized partial regression coefficient which splits correlation coefficients into the measure of direct and indirect contributions of various independent characters on a dependent character. The correlation coefficients between grain yield and yield attributing characters and physiological traits were divided into the corresponding direct and indirect effects through cause and effect analysis and the results were presented in Table 3 and Fig1.

Path coefficient analysis revealed that high positive direct effect on grain yield per plant at phenotypic level was exerted by fodder yield (0.830), harvest index (0.711), main panicle weight (0.228), SCMR (0.074) and SLA (0.074), number of productive tillers per plant (0.055), panicle length (0.048) and days to fifty percent flowering (0.011). Hence indirect selection for these traits would be rewarding for improvement of grain yield in little millet. Similar results were in accordance with findings of Jyothsna *et al.* (2016) and Anuradha *et al.* (2017) [7, 3].

Fodder yield per plant and harvest index had high direct effect with grain yield, negligible direct effects observed in days to 50% flowering, number of productive tillers per plant, SPAD chlorophyll meter reading and specific leaf area. Moderate direct effects recorded with main panicle weight per plant. Negative negligible direct effects recorded in plant height, 1000 seed weight and days to maturity.

The high direct effect of fodder yield and harvest index suggests true relationship with grain yield and hence direct selection for these traits would be rewarding for the enhancement of grain yield in little millet. Similar results were reported earlier by Anuradha *et al.* (2017) [3] in little millet and Arya *et al.* (2017) [2] in barnyard millet.

Table 2: Estimates of direct and indirect effects of yield components and physiological traits in little millet

Character (s)	DFF	DM	PH	NPT	PL	MPW	1000SW	FY	HI	SCMR	SLA	Correlation with grain yield
DFF	0.011	-0.062	0.002	-0.002	-0.007	0.057	0.012	-0.006	0.256	-0.014	0.013	0.258
DM	0.010	-0.068	-0.003	-0.001	-0.005	0.074	0.014	0.059	0.243	-0.010	0.015	0.328*

PH	0.000	-0.004	-0.046	0.009	0.023	0.112	0.006	0.599	-0.190	0.026	0.010	0.544**
NPT	0.000	0.001	-0.008	0.055	0.014	-0.027	-0.001	0.279	-0.075	0.003	0.003	0.243
PL	-0.002	0.007	-0.022	0.016	0.048	-0.004	0.002	0.191	-0.099	0.009	-0.008	0.138
MPW	0.003	-0.022	-0.023	-0.006	-0.001	0.228	0.004	0.400	0.185	0.023	0.008	0.798**
1000 SW	-0.003	0.020	0.006	0.002	-0.002	-0.020	-0.047	-0.035	0.076	-0.012	-0.025	-0.041
FY	0.000	-0.005	-0.034	0.018	0.011	0.110	0.002	0.830	-0.333	0.017	0.021	0.637**
HI	0.004	-0.023	0.012	-0.006	-0.007	0.059	-0.005	-0.389	0.711	0.000	-0.024	0.333*
SCMR	-0.002	0.009	-0.016	0.002	0.006	0.071	0.008	0.186	-0.001	0.074	0.013	0.350**
SLA	0.002	-0.013	-0.006	0.002	-0.005	0.025	0.016	0.235	-0.230	0.013	0.074	0.112

* Significant at 5% level ** Significant at 1% level

Residual effect (Phenotypic): 0.04141; Diagonals: Direct effects; Off diagonals: Indirect effects

DFF: Days to 50% flowering; DM: Days to maturity; PH: Plant height(cm); NPT: Number of Productive tillers per plant; PL: Panicle length (cm); MPW: Main panicle weight per plant (g); 1000SW: 1000 Seed weight (g); FY: Fodder yield per plant (g); HI: Harvest index (%); SCMR:SPAD Chlorophyll meter reading; SLA: Specific leaf area (cm^2/g); GY: Grain yield per plant (g).

Conclusion

Grain yield was significant positively correlated with plant height, main panicle weight, fodder yield, harvest index and SPAD chlorophyll meter reading. Fodder yield per plant and harvest index had high direct effect with grain yield. Improvement for grain yield in little millet can be made through indirect selection on these characters.

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