Original Research Article

Delineation of selection criterion using correlation and path analysis in forage pearl millet (*Pennisetum glaucum* (L.) R. Br.)in North Gujarat condition

ABSTRACT

Knowledge of genetic and phenotypic association among economic traits helps plant breeders in outlying efficient breeding strategies for development of high yielding forage pearl millet variety. An experiment was conducted at the research farm of SardarkrushinagarDantiwada Agricultural University, Sardarkrushinagar, Gujarat to evaluate plant characteristics associated with green forage yield and its attributes in forage pearl millet [*Pennisetum glaucum* (L.) R. Br.] genotypes in north Gujarat condition through correlation and path analyses during 2023. Twelve independent and 1 dependent variable were evaluated for the character association analysis of the 30 forage pearl millet genotypes. Selection and evaluation was performed using Randomized Block Design with three replications. Five plants selected randomly from each replicated lines and subjected to data assortment and analysis using R Studio. The green forage yield per plant had positive and significant correlation with plant height,number of tiller per plant,stem thickness, leaf length,leaf width,and dry fodder yield per plant at both genotypic and phenotypic level. Path analysis revealed the importance of leaf width and dry fodder yield per plant by showing high and positive direct effects towards green forage yield per plant. These characters also exhibited significant and positive association at the genotypic level and phenotypic with green forage yield per plant. Hence, these traits could be considered as the vital component characters for development of high yielding genotypes in forage pearl millet.

***Keywords*:** *forage pearl millet, green forage yield per plant, correlation, path analysis*

INTRODUCTION

Pearl millet serves as a dual-purpose drought-resistant crop, particularly valuable for fodder production. The appeal of pearl millet's green fodder is augmented by its drought resilience and absence of hydrogen cyanide (HCN) content, rendering it safe for cattle consumption at all growth stages [1]. The pearl millet is an annual, tilleringdiploid (2n = 2x = 14) crop plant that belongs to the family Poaceae and sub-family Paniceidae. In India, pearl millet has having 7.55 million hectare area, 9.22 million tonnes of production, and 1374 kg/ha productivity in the year 2020-21 [2]. In India, it is mainly grown in Rajasthan, Uttar Pradesh, Gujarat, Haryana and Maharashtra. In Gujarat, the area, production, and productivity of pearl millet are 0.46 million hectares, 1.008 million tonnes, and 2191 kg/ha, respectively in the year 2021- 22 [3]. Within the total net cropped area, hardly 5 per cent is used to grow fodder. That's why, in recent years India has been facing an acute shortage of feeds and fodder. The demand will reach 1012 million tonnes of green fodder and 631 million tonnes of dry fodder by the year 2050. At the present level of growth in forage resources, there will be an 18.4% deficit in green fodder and a 13.2% deficit in dry fodder within the year 2050. To meet the deficit, green forage has to grow at 1.69% annually [4]. There is little or no scope for increasing the cultivation area due to rapid urbanization and industrialization *etc*. Therefore, there is an urgent need to emphasize increasing forage crop production per unit area to meet the fodder requirement by evolving high yielding and improved varieties of forage crops as well as innovative forage production technology. The productivity and growth of livestock are closely linked with the biomass and quality of forages.

Analysing the coefficients of correlation between the traits that either directly or indirectly affect yield is important when conducting a selection program[5]. Correlation estimates between yield and its component characters play a pivotal role in guiding the selection of desirable plant types and designing effective breeding programs. Correlation coefficients quantify the extent of association, whether influenced by genetic or environmental factors, between two or more characters, thereby serving as a fundamental principle for selection strategies [6], [7], [8], [9]. This is owing to the fact that most of the characters are inter related, and a changed in one is likely to influence the other, thus the net benefit received by selecting one may be counterbalanced by a simultaneous change in another. Therefore, correlation is helpful in determining the component characters of a complex trait like green forage yield. It did not, however, indicate the relative significance of the direct and indirect effects of these constituents [10]. These may be determined through path analysis, with the unfolding of correlation coefficient for analysed traits. Path coefficient estimation provides information about the direct and indirect effects of yield attributes about yield. It shows how attributing characters influence the yield by their path values, whether they affect yield directly or via influencing other interrelated characters [11].

MATERIALS AND METHODS

The experimental materials consist of 30 forage pearl millet genotypes were grown during July-October 2023 at research farm of SardarkrushinagarDantiwada Agricultural University, Sardarkrushinagar, Gujarat which is located at the 24°-19° North Latitude and 72°-19° East Longitude with an altitude of 154.52 meters above mean sea level situated in the North Gujarat Agro-climatic Zone. The experimental material was provided by Main Forage Research Station, Anand Agriculture University, Anand.Selection and evaluation was performed using Randomized Block Design with three replications with row to row spacing of 30 cm and plant to plant spacing of 15 cm. All the recommended package of practices were adapted to raise the healthy crop. Quantitative and qualitative traits, viz. days to flowering,days to maturity,plant height (cm),number of tiller per plant,stem thickness (cm), number of leaf per plant, leaf length (cm),leaf width (mm) ,leaf: stem ratio, green forage yield per plant (g), dry fodder content %, dry fodder yield per plant (g) and crude protein content % were recorded for evaluation. Observations were collected on 5 arbitrarily selected pearl millet plants from each line and means were calculated for all the traits excluding days to flowering and days to maturity which were documented on plot basis.Crude protein content (%) was estimated from an oven dried sample following nitrogen estimation by Kjeldahl method [12]. Crude protein content was calculated by multiplying the percentage of nitrogen with a factor of 6.25. The genotypic (r_g) and phenotypic (r_p) correlation coefficient were calculated as under by adopting the procedure explained by [13].The cause-and-effect, interrelationship between two variables can't be estimated from simple correlation coefficient analysis. Therefore, the correlation among the different character combinations was utilized to construct the path coefficient analysis suggested by [14] and used by [15]. Replicated data were analysed using R package variability v.0.1.0 [16].

RESULT AND DISCUSSION

CORRELATION ANALYSIS: As green forage yield per plant is a complex quantitative character which is generally influenced byenvironment, any direct selection done for yield is not effective. Therefore, correlation studies traits that will be considered for effective choice of increasing green forage yield per plant and quality in terms of crude protein content. In order to conduct a successful selection method, crop development programs strongly depend on the availability of sufficient diversity and correlation among distinct traits. Understanding the relationships between various components and their respective contributions is crucial for selection [17], [18]. The genetic improvement in dependent trait that is green forage yield per plant can be achieved by applying strong selection to character which is genetically correlated with the dependent traits called as correlated response. In the present study, correlation coefficient at phenotypic and genotypic levels between the green forage yield per plant and its component characters and also between the component characters themselves has been applied to all possible combination. Table 1 and Table 2 represent the findings.In general, the genotypic correlation coefficient was significantly higher than phenotypic correlation coefficient indicating the inherent association among various studied traits and phenotypic value is lessened by the significant interaction of environment.Less significant phenotypic correlation coefficients than genotypic correlation coefficients were also observed in a number of previous study findings[19], [20].

The genotypic and phenotypic association of green forage yield per plant was positive and highly significant correlated with plant height (r_g=0.6688, r_p=0.5953), number of tiller per plant (r_g=0.6387, r_p=0.5471), stem thickness (r_g=0.8161, r_p=0.6885), leaf length (r_g=0.6450, r_p=0.4418), leaf width (r_g=0.9244, r_p=0.7269), and dry fodder yield per plant (r_g=0.8567, r_p=0.8045) indicated that these characters are the primary yield determinants.Selection criteria based on these traits would be beneficial for improvement of green forage yield per plant in forage pearl millet. This further helps in simultaneous improvement of both highly correlated traits.According to correlation data from the present study, it is possible that the aforementioned characteristics could be enhanced simultaneously as a result of coinheritance.Similar results also found by [21], [22] for plant height, leaf length and dry matter yield per plant; [23] for stem thickness; [24] for plant height, leaf length, leaf width and dry matter yield per plant; [25] for plant height and dry matter yield per plant and [26] for dry matter yield per plant; [27] for plant height, stem thickness, and dry fodder yield per plant.Green forage yield per plant was negative and significant correlated with days to maturity (r_g=-0.8059, r_p=-0.6236). Days to maturity is inversely proportional to green forage yield per plant. This relation showed that if genotype takes more time for maturity it leads to lower green forage yield per plant.[28] showed negatively significant results with green fodder yield which is contradictory to above result.Non-significant association of green forage yield per plant was found with number of leaves per plant and days to flowering and crude protein content at both genotypic and phenotypic level indicating the independence of these character from green forage yield per plant.Extent of crude protein content is the crucial character in forage pearl millet as it is essential nutrition in livestock feed. There was non-significant association of crude protein content with green forage yield per plant. Therefore, indirect selection for these characters should be done in forage pearl millet. Result for the crude protein content was not following the favourable trend in the current study. Deviation in this result is might also be due to error while taking observations or sampling error. These factors must be considered when building a complete selection program since the undesirable associations of some of the component characters may act as a barrier to the development of a program containing these attributes. Contradictory results for crude protein content was reported by [22], [24], [29].

Table 1: Genotypic correlation coefficient for different characters in forage pearl millet

Characters	DF	DM	PH	NTP	ST	NLP	LL	LW	LSR	DFC	DFYP	CPC	GFYP
DF	**1.0000**	-0.3490	0.3915*	0.1461	0.0590	0.2777	0.3912 *	0.1978	0.0979	0.4656**	0.3626*	0.0681	0.1043
DM		**1.0000**	-0.6877**	-0.9542**	-0.8612**	-0.4451*	-0.4577*	-0.8536**	-0.0632	-01836	-0.9386**	-0.0101	-0.8059**
PH			**1.0000**	0.5810**	0.6437**	0.2297	0.5107**	0.7082**	0.2707	0.0764	0.7392**	0.2815	0.6688**
NTP				**1.0000**	0.7969**	0.4437*	0.3676*	0.6643**	0.0937	0.1238	0.7430**	0.0956	0.6387**
ST					**1.0000**	0.2429	0.3858*	0.9259**	0.2472	-0.1121	0.7762**	0.0848	0.8161**
NLP						**1.0000**	0.0178	0.1623	0.0382	0.3176	0.4048*	0.1871	0.1590
LL							**1.0000**	0.5313**	0.2099	-0.1751	0.5689**	-0.1584	0.6450**
LW								**1.0000**	0.3009	-0.2811	0.8452**	-0.0109	0.9244**
LSR									**1.0000**	-0.0126	0.3194	-0.0138	0.3285
DFC										**1.0000**	0.2332	0.2814	-0.2711
DFYP											**1.0000**	0.0942	0.8567**
CPC												**1.0000**	-0.0248
GFYP													**1.0000**

*, ** significant at 5% and 1% level of significance, respectively

Where, **DF**= Days to 50% flowering, **DM**= Days to maturity, **PH**= Plant height (cm), **NTP**= Number of tillers per plant, **ST**= Stem Thickness (cm), **NLP**= Number of Leaves per plant, **LL**= Leaf length (cm), **LW**= Leaf width (mm), **LSR**= Leaf: Stem Ratio, **DFC**= Dry Fodder Content (%), **DFYP**= Dry Fodder Yield per Plant (g), **CPC**= Crude Protein content (%), **GFYP**= Green Forage Yield per Plant (g)

Table 2: Phenotypic correlation coefficient for different characters in forage pearl millet

Characters	DF	DM	PH	NTP	ST	NLP	LL	LW	LSR	DFC	DFYP	CPC	GFYP
DF	**1.0000**	-0.2683*	0.3307**	0.1409	0.0657	0.1932	0.2378*	0.1550	0.1163	0.3425**	0.2791**	0.0525	0.0563
DM		**1.0000**	-0.5941**	-0.7676**	-0.6832**	-0.3649**	-0.3087**	-0.6173**	-0.0463	-0.1165	-0.7267**	-0.0657	-0.6236**
PH			**1.0000**	0.5355**	0.5641**	0.1882	0.3853**	0.6285**	0.2343*	0.0267	0.6442**	0.2449*	0.5953**
NTP				**1.0000**	0.7120**	0.3497**	0.2783**	0.5262**	0.0639	0.0795	0.6284**	0.0643	0.5471**
ST					**1.0000**	0.1765	0.2611*	0.7124**	0.1937	-0.0853	0.6592**	0.0517	0.6885**
NLP						**1.0000**	0.0095	0.1435	0.0197	0.2933**	0.2834**	0.1869	0.0489
LL							**1.0000**	0.3531**	0.1142	-0.1155	0.3655**	-0.0990	0.4418**
LW								**1.0000**	0.2413*	-0.1536	0.6748**	-0.0355	0.7269**
LSR									**1.0000**	0.0019	0.2881**	-0.0177	0.2818**
DFC										**1.0000**	0.2516*	0.1812	-0.3416**
DFYP											**1.0000**	0.0686	0.8045**
CPC												**1.0000**	-0.0248
GFYP													**1.0000**

*, ** significant at 5% and 1% level of significance, respectively

Where, **DF**= Days to 50% flowering, **DM**= Days to maturity, **PH**= Plant height (cm), **NTP**= Number of tillers per plant, **ST**= Stem Thickness (cm), **NLP**= Number of Leaves per plant, **LL**= Leaf length (cm), **LW**= Leaf width (mm), **LSR**= Leaf: Stem Ratio, **DFC**= Dry Fodder Content (%), **DFYP**= Dry Fodder Yield per Plant (g), **CPC**= Crude Protein content (%), **GFYP**= Green Forage Yield per Plant (g)

PATH ANALYSIS*:* Ever since coefficients of correlation merely reveal the interrelationships between the characters deprived of regard to cause and effect, it gains additional significance when divided in components of indirect and direct effects by path coefficient analysis[15]. Green forage yield per plant was deliberated as the dependent variable for analysis, and the other twelve characteristics were employed as the causative factors. Table 3 and Fig 1 represent the findings.Path analysis revealed the importance of leaf width and dry fodder yield per plant by showing high and positive direct effects towards green forage yield per plant. [21], [22], [24], [26],], [27], [30], [31],[32], and [33] reported similar results as they observed positive and high direct effect of dry matter yield per plant on green forage yield per plant. Contradictory results are shown by [22] and [24] by showing negative direct effect of leaf width on green forage yield per plant. Leaf length recorded low positive direct effects towards green forage yield per plant. The results are in agreement with the findings of [21] and [24] as they reported positive direct effect of leaf length on green forage yield per plant. These characters also exhibited significant and positive association at the genotypic level and phenotypic with green forage yield per plant. So, these traits may be considered as the most important yield contributing traits and due emphasis should be placed on these characters while breeding for high green forage yield per plant. Negligible and positive effect was recorded for days to maturity, number of tiller per plant, leaf: stem ratio and crude protein content. Similar results were found by [34], [35], [32] and [36]for days to maturity; [21], [37], [29], [35] and [34] for number of tiller per plant. Contradictory results shown by [22] by showing negative direct effect of crude protein content on green fodder yield per plant. Negative direct effect was shown by days to flowering, plant height, stem thickness, number of leaf per plant and dry fodder content. If the indirectly selected traits have a high heritability as well as correlation with green forage yield, a higher yield can be obtained. In order to indirect selection to be more effective certain combinations of heritability and correlation coefficient values must be present, according to [38]. Plant height, number of tiller per plant and stem thickness showed high indirect effect on green fodder yield per plant thorough leaf width and dry fodder yield per plant; leaf length and dry fodder yield per plant thorough leaf width and leaf width thorough dry fodder yield per plant. The residual effect (0.0532) reported in the present investigation indicated the presence of those independent traits which are associated with green forage yield genotypes were utilized in the study and provided good scope for improvement in green forage yield.

Conclusion:

Results of this study have clarified the significance of leaf width and dry fodder yield per plant which have a high significant positive association and positive direct effects on green forage yield as well as positive indirect effects on all other traits for green forage yield too. Concentrating on these traits in selection process along with other traits such as leaf length and number of tiller per plant will help in crop improvement programme in devising further breeding strategies and selection procedures to evolve high yielding varieties which will benefit the forage pearl millet growing farmers.

Table 3: Direct and Indirect effects of yield components on green forage yield in forage pearl millet

Sr. No.	Characters	DF	DM	PH	NTP	ST	NLP	LL	LW	LSR	DFC	DFYP	CPC	Genotypic correlation with GFYP
1	DF	**-0.1895**	-0.0230	-0.0150	0.0128	-0.0159	-0.0043	0.0672	0.1350	0.0015	-0.0514	0.1846	0.0024	0.1043
2	DM	0.0661	**0.0658**	0.0264	-0.0833	0.2321	0.0069	-0.0786	-0.5824	-0.0010	0.0203	-0.4780	-0.0003	-0.8059**
3	PH	-0.0742	-0.0453	**-0.0384**	0.0507	-0.1735	-0.0036	0.0877	0.4832	0.0043	-0.0084	0.3765	0.0098	0.6688**
4	NTP	-0.0277	-0.0628	-0.0223	**0.0873**	-0.2148	-0.0069	0.0631	0.4533	0.0015	-0.0137	0.3784	0.0033	0.6387**
5	ST	-0.0112	-0.0567	-0.0247	0.0696	**-0.2696**	-0.0038	0.0663	0.6317	0.0039	0.0124	0.3952	0.0030	0.8161**
6	NLP	-0.0526	-0.0293	-0.0088	0.0387	-0.0655	**-0.0155**	0.0031	0.1108	0.0006	-0.0351	0.2061	0.0065	0.1590
7	LL	-0.0742	-0.0301	-0.0196	0.0321	-0.1040	-0.0003	**0.1717**	0.3625	0.0033	0.0193	0.2897	-0.0055	0.6450**
8	LW	-0.0375	-0.0562	-0.0272	0.0580	-0.2496	-0.0025	0.0912	**0.6823**	0.0048	0.0310	0.4304	-0.0004	0.9244**
9	LSR	-0.0186	-0.0042	-0.0104	0.0082	-0.0666	-0.0006	0.0360	0.2053	**0.0158**	0.0014	0.1625	-0.0005	0.3285
10	DFC	-0.0883	-0.0121	-0.0029	0.0108	0.0302	-0.0049	-0.0301	-0.1918	-0.0002	**-0.1104**	0.1187	0.0098	-0.2711
11	DFYP	-0.0687	-0.0618	-0.0284	0.0649	-0.2092	-0.0063	0.0977	0.5767	0.0050	-0.0258	**0.5093**	0.0033	0.8567**
12	CPC	-0.0129	-0.0007	-0.0108	0.0083	-0.0229	-0.0029	-0.0272	-0.0074	-0.0002	-0.0311	0.0480	**0.0350**	-0.0248

Residual Effect: 0.0532 *, ** Significant at P = 0.05 level and P = 0.01 level respectively

Where, **DF**= Days to 50% flowering, **DM**= Days to maturity, **PH**= Plant height (cm), **NTP**= Number of tillers per plant, **ST**= Stem Thickness (cm), **NLP**= Number of Leaves per plant, **LL**= Leaf length (cm), **LW**= Leaf width (mm), **LSR**= Leaf: Stem Ratio, **DFC**= Dry Fodder Content (%), **DFYP**= Dry Fodder Yield per Plant (g), **CPC**= Crude Protein content (%), **GFYP**= Green Forage Yield per Plant (g)

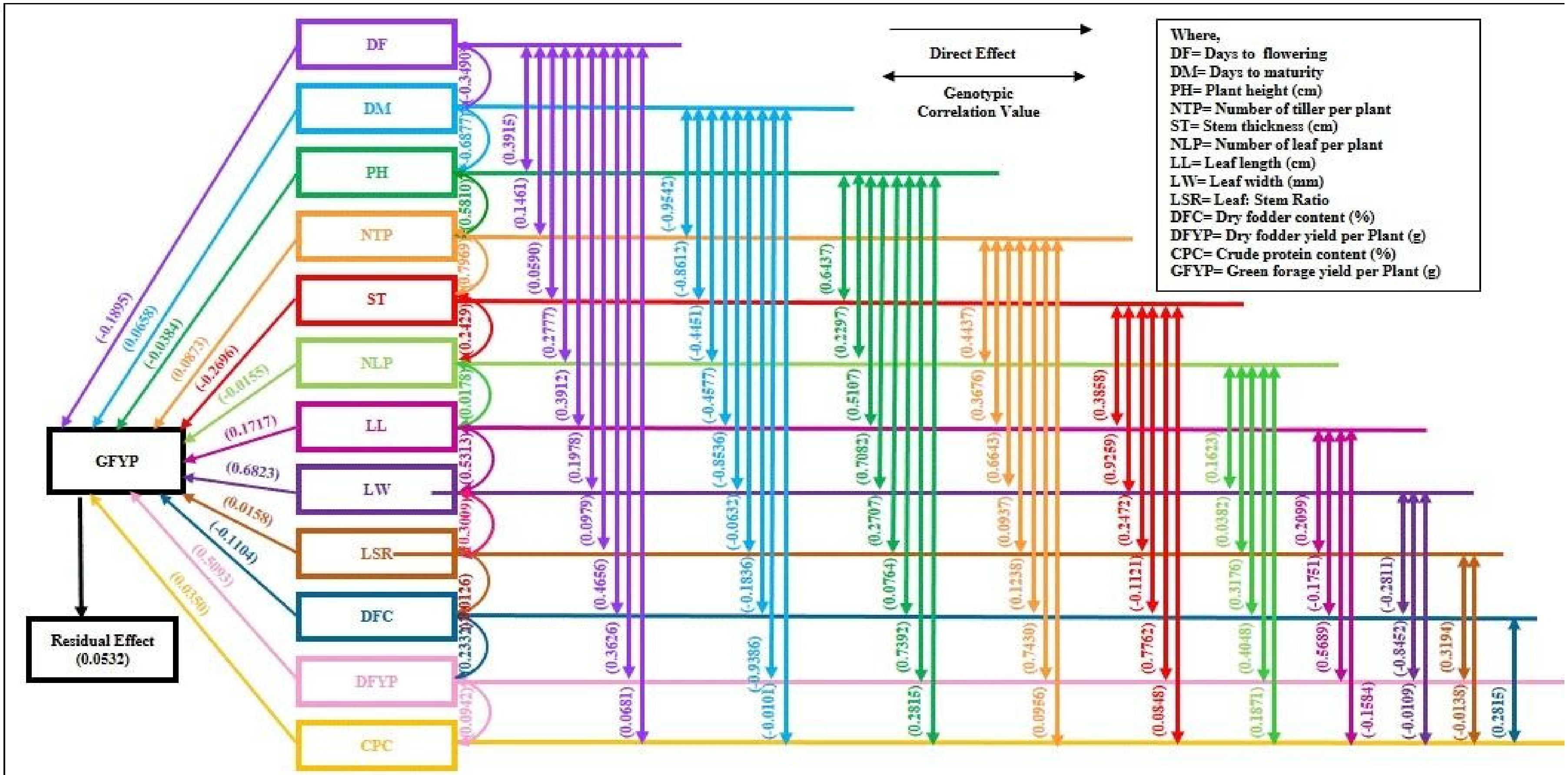

Figure 1: Diagrammatic representation of genotypic path analysis in forage pearl millet

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