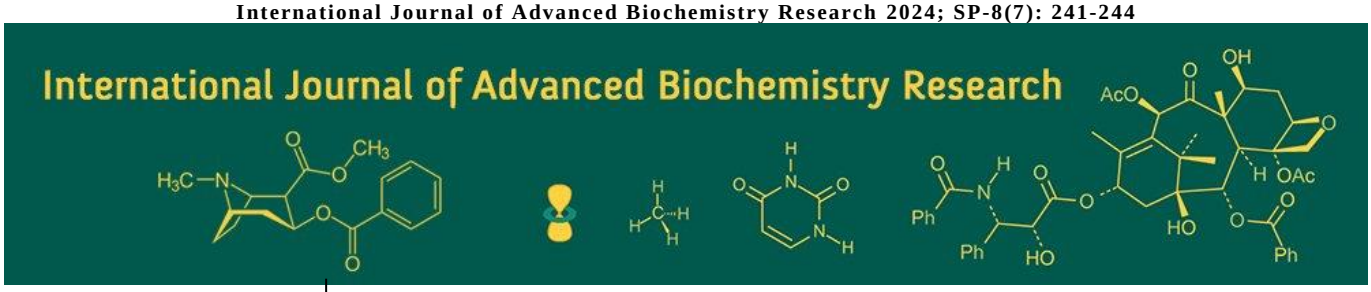

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Correlation and path coefficient analysis for yield and yield contributing traits in proso millet (*Panicum miliaceum* L.)

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Abstract
The present study character association and path coefficient analysis in seventy genotypes with four checks in proso millet was carried out during Late *rabi*, 2022 at PG research farm RCSM College of Agriculture Kolhapur. The experiment was laid out in randomized block design with two replications to assess seventy genotypes of proso millet with four checks. The correlation coefficient indicated that grain yield showed highly significant and positive association with fodder yield per plant, productive tillers per plant, ear head length, 1000 grain weight, days to 50 percent flowering, plant height and days to maturity. Path coefficient analysis revealed that fodder yield per plant showed highest positive direct effect on grain yield per plant which is followed by, productive tillers per plant, days to 50 percent flowering and 1000 grain weight. Thus, direct selection for these traits will be beneficial in yield improvement programme.

Keywords: Proso millet, path analysis, correlation, analysis of variance

Introduction
Proso millet (*Panicum miliaceum* (L.) (2n = 4x = 36) is an important minor millet belonging to one of the important family Gramineae. It is a tetraploid, self-pollinated and short duration C_4 crop. It is also called as Hog millet, Common millet, Broomcorn millet, White millet and yellow millet. As it is a short duration crop and completes its life cycle within 60 to 100 days with minimum water requirement, it is perfectly suitable to cultivated during hot, dry and short summer seasons (Uddin, 2021) [11]. It is errect annual herbaceous plant with plant height varying from 45-100 cm and shallow fibrous root system. The roots are shallow and fibrous. The leaves are slender, linear and the leaf sheath usually encloses the entire internode. The inflorescence is a much branched panicle without bristles and spikelets are present at the tips. The last or the fourth glume usually encloses a perfect flower which sets a grain. The palea and glume are firmly attached to the grain. The seeds may be creamy white, yellow, black or red.

Proso millet is known for several health benefits. It has high nutritive value as compared to major cereal grains. It contains Protein - 11%, Fat - 3.5%, Crude fiber - 9%, Ash - 3.5%, Starch - 56.1%, Total dietary fiber - 8.5%. It is a good source of minerals like Calcium, Phosphorus, Potassium, Sodium, Magnesium, Iron, Manganese, Zinc, Thiamin and Nicotonic acid. It also contain all essential amino acids like Isoleucine, Leucine, Metheonine, Phenyl - alanine, Threonine, Tryptophan and Valine. It is an ideal food for people with type 2 diabetes mellitus and cardiovascular disease. It can be used as a prebiotic, non - digestible carbohydrates in proso millet helps in the growth of desirable microflora in the intestine. It can prevent constipation and is therefore quite effective as preventive food against colon cancer. It is also beneficial for Nervous system, Lowering cholesterol, Have an anti-ageing property, Preventing pellagra conditions, For strengthening of bones (Das *et al*, 2019) [2]. It can be used alternative to existing starch for its quality characteristics and provides insight to many food processing industries (Banagar *et al*., 2021) [1].

Correlation is the mutual relationship between the variables, it aids in determining the most effective procedures for selection of superior genotypes. When there is positive correlation between major yield components, breeding strategies would be very effective, but on the reverse, selection becomes very difficult.

The estimates of correlation coefficient alone may be often misleading due to mutual cancellation of component characters. So, the correlation coupled with a path analysis is more effective tool in the study of yield contributing characters. Path coefficient analysis is an important technique for partitioning the correlation coefficient into direct and indirect effect of the causal components on the complex component (Kumari A., 2016) [6]. Present investigation was carried with the utilization of seventy four genotypes of proso millet to assess the yield attributing characters towards the grain yield per plant by using correlation and path analysis studies.

Materials and Methods

The present investigation was conducted at post graduate research farm, R.C.S.M. College of Agriculture, Kolhapur during Late *rabi*, 2022. The experimental material consisted of 70 proso millet genotypes with 4 checks which were collected from IIMR, Hyderabad. The experiment was laid out in randomized block design. The field was divided into two homogenous replication blocks. Seventy-four genotypes were planted randomly in two replications. Each entry was represented by a single row of 3 m length spaced at 30 cm between the rows and 10 cm between the plants within the rows. Correlation between nine characters was estimated according to the method given by Singh and Chaudhary (1977) [10]. Direct and indirect effects were estimated as described by Dewey and Lu (1959) [3].

Results

The analysis of variance for nine characters is presented in Table 1. Analysis of variance revealed that there were highly significant differences among the genotypes for all characters under study, showing wide variation in seventy four genotypes of proso millet.

Table 1: Analysis of variance for different characters in proso millet

Sr. No.	Characters	Mean Sum of Square		
		Replication (DF=1)	Treatment (DF=73)	Error (DF=73)
1	Days to 50% flowering (No.)	0.027	45.283**	1.58
2	Days to maturity (No.)	0.168	37.952**	2.77
4	Plant height (cm)	39.129	260.171**	60.45
3	Productive tillers/plant (No.)	0.011	9.338**	0.40
5	Ear head length (cm)	9.180	18.192**	3.75
6	1000 grain weight (g)	0.00056	1.582**	0.027
7	Grain yield/plant (g)	0.037	21.927**	1.78
8	Fodder yield/plant (g)	11.132	271.396**	22.84
9	Protein content (%)	0.004	1.536**	0.069

*, ** significant at 5% and 1% probability respectively.

Correlation

Yield is a complex character and the result of interaction between various yield components. The success of any breeding programme depends on the efficiency of selection. Thus, it helps the breeder in selection of characters for future breeding programme.

The genotypic correlation coefficients between yield and its related components in all possible comparisons for both the environmental conditions were presented in Table no. 2

Grain yield showed highly significant and positive association with fodder yield per plant (0.9962), productive tillers per plant (0.9238), ear head length (0.8848), 1000 grain weight (0.6436), days to 50 percent flowering (0.4283), plant height (0.2731) and days to maturity (0.2311). The character protein content (-0.0613) was negatively associated and non-significant at the genotypic level. There was negative association between protein content (-0.0613) with grain yield per plant which was desirable though it was not significant.

Table 2: Genotypic correlation of 9 characters in proso millet

Sr. No.	Characters	Days to 50% flowering (No.)	Days to maturity (No.)	Plant height (cm)	Productive tillers/plant (No.)	Ear head length (cm)	1000 grain weight (g)	Fodder yield/Plant (g)	Protein content (%)	Grain yield/Plant (g)
1.	Days to 50% flowering (No.)	1.000	0.9098**	0.3897**	0.2109	0.2230	0.1174	0.4214**	-0.0943	0.4283**
2.	Days to maturity (No.)		1.000	0.2765*	0.0654	0.0248	- 0.0140	0.2222	-0.0841	0.2311*
3.	Plant height (cm)			1.000	0.1342	0.2470*	0.0848	0.2868*	0.1137	0.2731*
4.	Productive tillers/plant (No.)				1.000	0.8938**	0.6723**	0.9109**	-0.0920	0.9238**
5.	Ear head length (cm)					1.000	0.6891**	0.8843**	-0.0491	0.8848**
6.	1000 grain weight (g)						1.000	0.6315**	-0.1116	0.6436**
7.	Fodder yield/Plant (g)							1.000	-0.0468	0.9962**
8.	Protein content (%)								1.000	-0.0613
9.	Grain yield/Plant (g)									1.000

*, ** significant at 5% and 1% probability respectively.

Similar results were also reported by Verulkar *et al*., (2014) [12], Karad and Patil (2013) [5], Hawlader (1991) [4] and Sen and Hamid (1986) [9].

Days to 50 percent flowering was significantly and positively correlated with days to maturity (0.9098), fodder yield per plant (0.4214) and plant height (0.3897). It was positively and non-significantly correlated with ear head

length (0.2230), productive tillers per plant (0.2109) and 1000 grain weight (0.1174). While, negative and non-significant correlation with protein content (-0.0943).
Days to maturity exhibited highly significant and positive correlation with plant height (0.2765). It showed positive and non-significant correlation with fodder yield per plant (0.2222) productive tillers per plant (0.0654), ear head length (0.0248). And it is negative and non-significantly correlated with protein content (-0.0841) and 1000 grain weight (-0.0140).
Plant height exhibited positive significant correlation with fodder yield per plant (0.2868), and ear head length (0.2470) and moderate and positive correlation with productive tillers per plant (0.1342), protein content (0.1137) and 1000 grain weight (0.0848).
The character productive tillers per plant exhibited highly significant and positive correlation with fodder yield per plant (0.9109), ear head length (0.8938), 1000 grain weight (0.6723) and it is negatively and non-significantly correlated with protein content (-0.0920).
Ear head length showed highly significant and positive correlation with fodder yield per plant (0.8843) and 1000 grain weight (0.6891). It is negatively and non- significantly correlated with protein content (-0.0491).
1000 grain weight was highly significant and positively correlated with fodder yield per plant (0.6315). It showed negative non - significant correlation with protein content (-0.1116).
Fodder yield per plant was highly significant and positively correlated with grain yield per plant (0.9962). It showed negative non-significant correlation with protein content (-0.0468) and the character protein content exhibited negative and non-significant correlation with grain yield per plant (-0.0613). Similar findings were also reported by Verulkar *et al*., (2014) [12].

Path analysis: Path coefficient analysis permits the partition of correlation coefficients into direct and indirect effects and helps in identifying the effective components and to get information on actual contribution of each component character to yield. The path analysis takes into account the cause and effect relationship between the variables by partitioning the association into direct and indirect effects through other independent variables. Path analysis along with correlation studies provides information on the nature and association between any two metric traits.
Path analysis splits the correlation coefficient into direct and indirect effects. Correlation along with path analysis proves more reliable for use in breeding programme. Yield is a dependable character and the result of several component traits. Some characters contribute directly towards yield, whereas, others indirectly affect the yield. Hence, there is necessary to study the direct and indirect effects of various characters on yield.
The characters which had highest positive direct effect on grain yield are fodder yield per plant (0.8568), productive tillers per plant (0.1433), days to 50 percent flowering (0.0716) and 1000 grain weight (0.0147) Thus, direct selection for these traits will be beneficial in yield improvement programme. While, the characters like days to maturity (-0.0316), ear head length (-0.0250), plant height (-0.0057) and protein content (-0.0029) exhibited negative direct effect on grain yield per plant. Similar results were also obtained by Nirmalakumari and Ventriventhan (2010) [7], Sen and Hamid (1986) [9], Karad and Patil (2013) [5], Verulkar *et al*., (2014) [12], Salini *et al*., (2010) [8].
The character days to 50 percent flowering imparted positive indirect effect on grain yield through the fodder yield per plant (0.3611), productive tillers per plant (0.0302), 1000 grain weight (0.0017) and protein content (0.0003), While, it imparted negative indirect on grain yield through days to maturity (-0.0288), plant height (-0.0022) and ear head length (-0.0056).
The character days to maturity had positive indirect effect on grain yield per plant through days to 50 percent flowering (0.0652), productive tillers per plant (0.0094), fodder yield per plant (0.1904), protein content (0.0002). While, it showed negative indirect effect on grain yield per plant through plant height (-0.0016), ear head length (-0.0006) and 1000 grain weight (-0.0002).

Table 3: Direct (diagonal) and indirect (above and below diagonal) path effects of 9 characters towards grain yield in proso millet

Characters	Days to 50% flowering (No.)	Days to maturity (No.)	Plant Height (cm)	Productive tillers/plant (cm)	Ear Head Length (cm)	1000 grain weight (g)	Fodder yield/plant (g)	Protein Content (%)
Days to 50% flowering (No.)	0.0716	0.0652	0.0279	0.0151	0.0160	0.0084	0.0302	-0.0068
Days to maturity (No.)	-0.0288	-0.0316	-0.0087	-0.0021	-0.0008	0.0004	-0.0070	0.0027
Plant Height (cm)	-0.0022	-0.0016	-0.0057	-0.0008	-0.0014	-0.0005	-0.0016	-0.0007
Productive tillers/plant (cm)	0.0302	0.0094	0.0192	0.1433	0.1281	0.0963	0.1305	-0.0132
Ear Head Length (cm)	-0.0056	-0.0006	-0.0062	-0.0223	-0.0250	-0.0172	-0.0221	0.0012
1000 grain weight (g)	0.0017	-0.0002	0.0012	0.0099	0.0101	0.0147	0.0093	-0.0016
Fodder yield/plant (g)	0.3611	0.1904	0.2457	0.7805	0.7577	0.5411	0.8568	-0.0401
Protein Content (%)	0.0003	0.0002	-0.0003	0.0003	0.0001	0.0003	0.0001	-0.0029
Grain yield/plant (g)	0.4283	0.2311	0.2731	0.9238	0.8848	0.6436	0.9962	-0.0613

R^2 = 0.9953, Residual effect - 0.0687

The character plant height imparted positive indirect effect via days to 50 percent flowering (0.0279), productive tillers per plant (0.0192), 1000 grain weight (0.0012), fodder yield per plant (0.2457). It showed indirect negative effect via days to maturity (-0.0087), ear head length (-0.0062) and protein content (-0.0003).
Number of productive tillers per plant exhibited positive indirect effect via days to 50 percent flowering (0.0151), 1000 grain weight (0.0099), fodder yield per plant (0.7805) and protein content (0.0003). It showed indirect negative effect via days to maturity (-0.0021), plant height (-0.0008) and ear head length (-0.0223).
The character ear head length imparted positive indirect effect on grain yield per plant via days to 50 percent flowering (0.0160), productive tillers per plant (0.1281), 1000 grain weight (0.0101), fodder yield per plant (0.7577) and protein content (0.0001). Whereas, it has indirect

negative effect via days to maturity (-0.0008) and plant height (-0.0014).

The character 1000 grain weight showed positive indirect effect on grain yield through days to 50 percent flowering (0.0084), days to maturity (0.0004), productive tillers per plant (0.0963), fodder yield per plant (0.5411) and protein content (0.0003). While, it imparted negative indirect effect on grain yield through plant height (-0.0005) and ear head length (-0.0172).

Fodder yield per plant showed positive indirect effect on grain yield per plant via days to 50 percent flowering (0.0302), productive tillers per plant (0.1305), 1000 grain weight (0.0093) and protein content (0.0001). It showed indirect negative effect via days to maturity (-0.0070), plant height (-0.0016) and ear head length (-0.0221).

The character protein content showed positive indirect effect on grain yield per plant via days to days to maturity (0.0027), ear head length (0.0012). It showed indirect negative effect via days to 50 percent flowering (-0.0068), plant height (-0.0007), productive tillers per plant (-0.0132), 1000 grain weight (-0.0016) and fodder yield per plant (-0.0401).

Conclusion

In conclusion, the analysis of variance across nine characters in proso millet genotypes revealed significant variations, indicating promising prospects for breeding programs. Correlation and path coefficient analyses further elucidated intricate relationships among yield components. Positive associations of grain yield with fodder yield per plant, productive tillers, and other traits underscore their direct impact on yield enhancement. Conversely, traits like days to maturity and certain morphological features exhibited indirect or negative effects on grain yield. These findings emphasize the importance of targeted trait selection in breeding for improving proso millet yields. Future breeding efforts should leverage these insights to optimize selection strategies effectively.

Discussion

In general correlation and path analysis concluded that fodder yield per plant (g), productive tillers per plant, ear head length (cm), 1000 grain weight (g) and days to 50 percent flowering influenced the grain yield more than any characters. Hence, it would be worthwhile to lay more emphasis on these characters in selection programme to improve the grain yield in proso millet.

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