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Correlation and path analysis studies in summer cultivated Kodo millet genotypes in relation with yield and yield attributing traits

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Abstract
The first step in enhancing grain yield in kodo millet through genetic improvement is to focus on indirect selection of traits related to yield. Correlation studies with 38 kodo millet germplasm accessions revealed that the traits like panicle length (0.610), flag leaf blade length (0.610), flag leaf blade width (0.572), days to physiological maturity (0.522), days to 50 percent flowering (0.511), plant height (0.427) and 1000 Grain weight (0.272) exhibited a highly significant and positive genotypic correlation with grain yield per earhead. A positive correlation implied that a rise in a single component characteristic would result in a higher grain production per earhead. Basal tiller number (-0.244) indicated a highly significant negative correlation. Path analysis indicated that among the correlated traits, flag leaf blade length (0.3377), flag leaf blade width (0.3319), days to 50 percent flowering (0.2985) and panicle length (0.246) reported highest positive direct effect. While, days to physiological maturity (-0.1554) showed negative direct effect on grain yield per earhead.

Keywords: Correlation, path analysis, yield components

Introduction

India is the native home of kodo millet, *Paspalum scrobiculatum* L. (2n=4x=40), which is primarily farmed for grain and fodder. In states like Madhya Pradesh, Maharashtra, Tamil Nadu and Chhattisgarh, 2.35 lakh hectares of kodo millet were planted in 2005-06. Approximately 72 percent of the total land used for kodo millet is shared between Madhya Pradesh and Chhattisgarh (Yadava, 1997) [18]. Although kodo millet has a theoretical output of 2000 kg/ha (Harinarayana, 1989) [6], its actual production is more like 250-1000 kg/ha (Hulse *et al.*, 1980) [7]. Finding a genotype with a greater yield is therefore urgently needed. In order to do this, an experiment was conducted to find characteristics associated with increased yield in kodo millet. Kodo millet contains low glycemic index, that shown to improve glucose tolerance in both healthy and diabetic subjects. Glycemic load (GL), which represents both quality and quantity of carbohydrates in a food and allows comparison of the likely glycemic effect of realistic portion of the different foods, is one of the properties of kodo that may be used to maintain or lower blood glucose response among diabetic and cardiovascular disease patients (Riccardi *et al.*, 2008) [12].

Understanding the relationship between yield and its constituent features greatly aids in the development of selection plans that result in the appropriate genotypes. It is necessary to identify the yield contributing traits that have a significant positive correlation with grain yield and have both direct and indirect effects toward grain yield in order to formulate the choice criteria for the crop improvement in kodo millet. For this purpose, a correlation and path coefficient analysis are required. While path analysis enables comprehension of the cause and effect of connected characters, correlation coefficient assessments often indicate the interrelationships of the characters. The path analysis shows whether a character's relationship to yield results from their direct influence on it or from their indirect impacts through other component characters. Considering the aforementioned details, the current study has been started.

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Materials and Methods
There were 38 different genotypes of kodo millet used as the experimental material for the correlation and path analysis studies as presented in Table 1. The AICRP on Small Millet, Zonal Agricultural Research Station, Shenda Park, Kolhapur, is the source of the experimental material. In the summer of 2024, field research was carried out at the AICRP on Small Millets, RSJRS, Kolhapur Center. Three replications and a randomized block design were used to set up the experiment. To understand the association among the characters, genotypic correlation coefficient was worked out by adopting method described by Singh and Chaudhary (1977) [14]. Path coefficient analysis was done according to the procedure suggested by Dewey and Lu (1959) [4].

Results and Discussion
The creation of selection strategies that produce the right genotypes is substantially aided by an understanding of the link between yield and its component traits. In every scenario, the genotypic correlation coefficients between yield and its associated components are calculated and displayed in Table 2. Path coefficient analysis provides an accurate picture of each trait's direct and indirect effects on other qualities. The findings for the direct and indirect impacts of various characteristics on grain yield per earhead depicted in Table 3.

A. Genotypic correlation
Correlation of grain yield per earhead with its components

In this experiment, the pre yield factors examined includes panicle length, flag leaf blade length, flag leaf blade width, days to physiological maturity, days to 50 percent flowering, plant height and 1000 Grain weight. These qualities are crucial to the yield contribution.

Grain yield per earhead exhibited a highly significant and positive genotypic correlation with the following traits: panicle length (0.610), flag leaf blade length (0.610), flag leaf blade width (0.572), days to physiological maturity (0.522), days to 50 percent flowering (0.511), plant height (0.427) and 1000 Grain weight (0.272). A positive correlation implied that a rise in a single component characteristic would result in a higher grain production per earhead. The basal tiller number (-0.244) showed highly significant negative correlation indicated that enhancing this particular attribute would result in a reduction of the grain yield per earhead in kodo millet. Similar results were reported by Lekha *et al.*, (2023) [9], Jeeva *et al.*, (2022) [8] and Anuradha *et al.*, (2020) [1] that grain yield per earhead was significantly and positively correlated with days to 50 percent flowering and panicle length. Anuradha *et al.*, (2020) [1] published similar results, showing a substantial and positive genotypic correlation between grain yield per earhead and days to physiological maturity. The current study's findings aligned with those of Sreeja *et al.*, (2015) [15] and Jeeva *et al.*, (2022) [8], who found a strong and positive correlation between grain yield per earhead and plant height. Vetriventhan *et al.*, (2019) [17] found a positive and significant correlation between the grain yield per earhead and flag leaf blade width. Jeeva *et al.*, (2022) [8] reported that flag leaf blade length had positive and significant correlation with grain yield per earhead. The same results were discovered for 1000 Grain weight in barnyard millet by Dhanalakshmi *et al.*, in 2019 [5].

Plant height exhibited positive and highly significant correlation with panicle length (0.611), 1000 Grain weight (0.558), flag leaf blade length (0.512) and flag leaf blade width (0.491). Basal tiller number (-0.199) showed negative but significant association. Non-significant association of plant height with days to physiological maturity reported by Choubey *et al.*, (2024) [2] and Anuradha *et al.*, (2020) [1]. Basal tiller number showed positive non-significant effect with 1000 Grain weight (0.179). Dalsaniya *et al.*, (2023) [3] and Lekha *et al.*, (2023) [9] estimated same for basal tiller number with days to physiological maturity. Results of Thakur *et al.*, (2020) [16] were matched with basal tiller number association with plant height and panicle length. Choubey *et al.*, (2024) [2], Jeeva *et al.*, (2022) [8] and Dalsaniya *et al.*, (2023) [3] were come up with the parallel findings for basal tiller number with flag leaf blade length. The findings of the current study, which showed a highly significant positive association of 1000 Grain weight with days to 50 percent flowering, days to physiological maturity and plant height, were consistent with the findings published by Sreeja *et al.*, (2015) [15].

B. Path Analysis
Direct effect of component characters on grain yield per earhead. In present study the character flag leaf blade length (0.3377) reported highest positive direct effect on grain yield per earhead followed by flag leaf blade width (0.3319), days to 50 percent flowering (0.2985) and panicle length (0.246). It showed that there was a real connection between these traits and the grain yield per earhead. Thus, in a program to enhance yield, direct selection for these qualities will be advantageous. Lekha *et al*., (2023) [9] noticed positive direct effect of days to 50 percent flowering and panicle length and negative direct effect of days to physiological maturity on grain yield per earhead. The results of the present study were in line with those reported by Choubey *et al*., (2024) [2] that flag leaf blade length and flag leaf blade width had positive and direct effect on grain yield per earhead. While, traits like 1000 Grain weight (-0.2442), basal tiller number (-0.1752), plant height (-0.1581) and days to physiological maturity (-0.1554) showed negative direct effect. The dependent variable is negatively impacted by increases in these qualities, as indicated by the negative direct effects. Therefore, breeding or culture programs should take measures to balance or reduce these features. Negative direct effect of plant height and basal tiller number observed by Nehru *et al*., (2024) [10] in barnyard millet. Patel *et al*., (2023) [3] noticed negative direct effect of 1000 Grain weight on grain yield in finger millet.

1000 Grain weight exhibited positive indirect effect on grain yield per earhead via flag leaf blade length (0.1733), flag leaf blade width (0.1171), days to 50 percent flowering (0.089) and panicle length (0.0604). Indirect positive effect of 1000 Grain weight on grain yield per earhead through flag leaf blade length and width was recorded by Choubey *et al*., (2024) [2]. The character plant height exhibited positive indirect effect on grain yield per earhead via flag leaf blade length (0.173), flag leaf blade width (0.1628), panicle length (0.1502), days to 50 percent flowering (0.0554) and basal tiller number (0.0349). Dalsaniya *et al.*, (2023) [3] observed that plant height indirect positive on grain yield per earhead via days to 50 percent flowering, flag leaf blade length, flag leaf blade width. The residual value in the present study was 0.5737 suggests that some more traits like number of productive tillers per plant, no. of panicles per plant, peduncle length, harvest index etc. need to be included in future for better understanding of the yield components.

Table 1: List of kodo millet genotypes included in the study

Sr. No.	GENOTYPE	Sr. No.	GENOTYPE
1.	KOP-KM-23-01	20.	KOP-KM-23-24
2.	KOP-KM-23-02	21.	KOP-KM-23-25
3.	KOP-KM-23-03	22.	KOP-KM-23-31
4.	KOP-KM-23-04	23.	KOP-KM-23-32
5.	KOP-KM-23-07	24.	KOP-KM-23-33
6.	KOP-KM-23-08	25.	KOP-KM-23-35
7.	KOP-KM-23-09	26.	KOP-KM-23-36
8.	KOP-KM-23-10	27.	KOP-KM-23-38
9.	KOP-KM-23-11	28.	KOP-KM-23-39
10.	KOP-KM-23-12	29.	KOP-KM-23-40
11.	KOP-KM-23-13	30.	KOP-KM-23-43
12.	KOP-KM-23-14	31.	KOP-KM-23-44
13.	KOP-KM-23-15	32.	KOP-KM-23-45
14.	KOP-KM-23-16	33.	KOP-KM-23-46
15.	KOP-KM-23-17	34.	KOP-KM-23-47
16.	KOP-KM-23-18	35.	KOP-KM-23-48
17.	KOP-KM-23-21	36.	KOP-KM-23-49
18.	KOP-KM-23-22	37.	KOP-KM-23-50
19.	KOP-KM-23-23	38 (Ch).	RK 390-25

Table 2: Genotypic correlation coefficients of nine characters in 38 genotypes of kodo millet

Trait	DFF	DPM	PH	PL	FLBL	FLBW	BTN	GW	GYPE
DFF	1.000	0.923**	0.186*	0.586**	0.283**	0.403**	0.046	0.298**	0.511**
DPM		1.000	0.176	0.606**	0.354**	0.366**	0.101	0.273**	0.522**
PH			1.000	0.611**	0.512**	0.491**	-0.199*	0.558**	0.427**
PL				1.000	0.525**	0.512**	0.191*	0.245**	0.610**
FLBL					1.000	0.502**	-0.146	0.513**	0.605**
FLBW						1.000	-0.074	0.353**	0.572**
BTN							1.000	0.179	-0.244**
GW								1.000	0.272**
GYPE									1.000

Where,
DFF - Days to 50 percent flowering
DPM - Days to physiological maturity
PH - Plant height
PL - Panicle length
FLBL - Flag leaf blade length
FLBW - Flag leaf blade width
BTN - Basal tiller number
GW - 1000 Grain weight
GYPE - Grain yield per earhead

Table 3: Direct (diagonal) and indirect (above and below diagonal) effects of different characters towards grain yield per ear head at genotypic level in kodo

Trait	DFF	DPM	PH	PL	FLBL	FLBW	BTN	GW
DFF	0.2985	0.2756	0.0554	0.1751	0.0845	0.1202	0.0136	0.089
DPM	-0.1435	-0.1554	-0.0274	-0.0941	-0.0549	-0.0568	-0.0158	-0.0424
PH	-0.0294	-0.0278	-0.1581	-0.0965	-0.081	-0.0776	0.0315	-0.0882
PL	0.1443	0.149	0.1502	0.246	0.1292	0.126	0.0469	0.0604
FLBL	0.0956	0.1194	0.173	0.1774	0.3377	0.1695	-0.0493	0.1733
FLBW	0.1337	0.1213	0.1628	0.1701	0.1666	0.3319	-0.0247	0.1171
BTN	-0.008	-0.0178	0.0349	-0.0334	0.0256	0.013	-0.1752	-0.0313
GW	-0.0729	-0.0667	-0.1363	-0.0599	-0.1253	-0.0862	-0.0436	-0.2442
GYPE	0.5105	0.5223	0.4268	0.6099	0.6048	0.5719	-0.2438	0.2715

Residual Effect = 0.5737
Where,
DFF - Days to 50 percent flowering
DPM - Days to physiological maturity
PH - Plant height
PL - Panicle length
FLBL - Flag leaf blade length
FLBW - Flag leaf blade width
BTN - Basal tiller number
GW - 1000 Grain weight
GYPE - Grain yield per earhead

Conclusions

The correlation analysis indicated that panicle length and flag leaf blade length showed highly significant positive relation with grain yield per earhead depicts increase in these traits directly proportionate with grain yield per earhead. While, basal tiller number exhibited negative association with grain yield per earhead infers indirect proportion. Path analysis partition the effect of variables into direct and indirect. Under this study it came to know that flag leaf blade length and flag leaf blade width manifested highest positive direct effect on grain yield per earhead followed by other characters except days to physiological maturity, plant height and 1000 Grain weight which demonstrated negative direct effect. Residual effect observed is in the value of 0.574 propounded unexplained variance in a variable that not related to research. So, implying the fact to consider number of productive tillers per plant and number of panicles per plant in coming experiment.

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