Original Research Article

Estimation of direct and indirect effect of yield attributing characters on grain yield in kodo millet *(Paspalum scrobiculatum L.)*

Abstract

The present study on "Estimation of direct and indirect effect of yield attributing characters on grain yield in kodo millet *(Paspalum scrobiculatum L.)*" was carried out at Instructional cum Research Farm of S.G. College of Agriculture and Research Station Kumhrawand, Jagdalpur, Chhattisgarh.In this study direct effect of productive tillers per plant on grain yield per plot was positive and high at genotypic and phenotypic level. Indicated true relationship of this trait and direct selection through this character will be effective.

Key words: Kodo millet, *Paspalum scrobiculatum*, Path coefficient, direct effect, indirect effect

Introduction

Kodo millet (*Paspalum scrobiculatum* L.) is belonging to family poaceae (gramineae). It is indigenous cereal of Indiaand grown for its grain and fodder purpose.Among cultivated and wild spp.,*Paspalum scrobiculatum var. scrobiculatum*is widely cultivated in India and other parts of the world as an important food crop, while *Paspalum scrobiculatum var. commersonii*is the wild spp. indigenous to India (De Wet *et al*., 1983).Kodo millet is gaining importance due to dual reasons like nutritional properties and stress tolerance (Kumar*et al.,* 2016). It contains protein 8.3 gram, fat 1.4 gram, CHO 65.9 gram,fibre 9.0 gram, minerals 2.6 gram, iron 0.5 mg, phosphorus 188 mg, calcium 27 mg, thiamine 0.33 mg, riboflavin 0.09 mg, niacin 0.2 mg per 100 g of seed (Deshpande *et al.*,2015).It provides low priced protein, minerals and vitamins in form of sustainable food (Yadava *et al.*,2006) The millet contains a prevention of constipation and slow release of glucose to the blood stream. Kodo contain water soluble fiber and this property may be utilized for maintainingor lowering blood glucose response among diabetic and cardiovascular disease patients, glycemic load (GL) representing both quality and quantity of carbohydrate in a food and allows comparison of the likely glycemic effect of realistic portion of the different foods and low glycemic index foods like kodo, have been shown to improve the glucose tolerance in both healthy and diabetic subjects (Riccardi *et al.*,2008). The restrains of kodo millet production including productivity in Bastar district of Chhattisgarh due to water stress condition, where monsoon sizes by second fortnight of September and crop ecology is more perplexeddue to lack of irrigation facilities in tribal farmers field. Kodo millet is suitable crop for this area because it require less amount of water, it is also suitable for upland. Kodo millet requires approximately 800–1200 mm of water annually and is well suited to sub humid aridity conditions (Chaurasiya, 2014).

MATERIALS AND METHODS

The present investigation was carried out at Instructional cum Research Farm of S.G. College of Agriculture and Research Station Kumhrawand, Jagdalpur, Chhattisgarh. Experiment was conducted in*kharif*season 2017 – 18.The region comes under sub-humid climate. The average annual rainfall of the area is 1544 mm.The experimental materials for present investigation consist of 80 germplasm of kodo millet. Among 80 germplasm 33 were selected for statistical analysis. The name of germplasm of kodo millet has been given in table1. The crop was sown on 11^{th} July 2017 at randomized block design with 2 replication. The seed was directly sown in line. The spacing of 22.5 cm within rows and 7.5 cm between the plants was followed. A basal dose of fertilizers 60:30:20 kg/ha of NPK was applied at the time of sowing. The crop was sown on plot size 2.25m x 3m. The regional crop production practices was followed. Observations were recorded on competitive and randomly chosen five plants from each genotype and from both replication, except flowering and maturity, they were recorded on plot basis. For genetic analysis grain yield and fodder yield were recorded on plot basis. The use of path coefficient analysis explains cause and effect relationship among the variables. This method permits breeder to identify relatively important components of a variable, on the basis of their direct and indirect influences. The direct and indirect effects both at genotypic and phenotypic level were estimated by taking grain yield per plant as dependent variable using path coefficient analysis suggested by Wright (1921) and Dewey and Lu (1959).

Table 1: List of selected 33 genotypes of kodo millet for genetic analysis

S.N.	Genotype name	S.N.	Genotype name	S.N.	Genotype name
1	BK-19	12	BK-48	23	BK-6
2	BK-20	13	BK-49	24	BK-7
3	BK-21	14	BK-50	25	BK-8
4	BK-34	15	BK-64	26	BK-9

5	BK-35	16	BK-81	27	BK-10
6	BK-36	17	PCGK-8	28	BK-11
7	BK-38	18	PCGK-12	29	BK-12
8	BK-42	19	BK-1	30	BK-13
9	BK-43	20	BK-2	31	BK-14
10	BK-45	21	BK-3	32	IK-01*
11	BK-46	22	BK-5	33	IK-02*

Result and Discussion

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 (Bharathi 2011). Direct effects means a trait directly affects another without being influenced by any trait; however when the relationship between two traits is mediated by one or more traits is referred as indirect effect. Knowledge of the association between yield and its components traits, and among the component trait themselves would allow for more effective selection for yield. To find out direct and indirect contributions of each of the characters on yield, path coefficient analysis was carried out. In computing path analysis, grain yield per plant is considered as a resultant (dependable) variable while the rest of the variables that were used as casual (independent) variables (John 2017). The present results of phenotypic and genotypic path coefficient of yield and yield contributing characters discussed here under which were presented in table 2 and 3.

Cause effect relationship with pre yield parameters.

Productive tillers per plant showed positive direct effect on grain yield (0.7149 and 0.2959) at genotypic and phenotypic level. It exhibited positive indirect effect through panicles per plant (0.0745 and 0.0298), panicle length (0.2340 and 0.0871), das to 50% flowering (0.1331 and 0.0543), das to maturity (0.2029 and 0.0823), test weight (0.3845 and 0.1288) while it laid negative indirect effect through plant height (-0.2146 and -0.0807), fodder yield per plot (-0.0141) at genotypic and phenotypic level. The direct positive effect means more number of productive tillers give more yield. In kodo millet tillers are affected by un-irrigated land and weedy nature of crop respectively. Sao *et al.* (2017)reported that plant height (0.192), number of panicles (0.176), number of productive tillers per plant (0.087) and fodder weight (0.002) had positive direct effect on grain yield. Similar findings were also reported by Kadam *et al.* (2009), Priyadharshini *et al.* (2011) and Ganapathey*et al.*(2011). Prakash and Vanniarajan in barnyard millet (2015) reported that grain yield per plant associated positively with productive tillers, 1000-grain weight, the number of grains per spikelet and finger number. While in finger millet Haradari*et al.* (2012) reported positive direct effect on grain yield, while the indirect positive effect through days to 50% flowering, days to maturity and plant height. Panicle per plant exhibited negative direct effect on grain yield (-0.5951), negative indirect effect through plant height (-0.2259), panicle length(-0.2367), days to 50% flowering (-0.0775), days to maturity (-0.0425) and negligible positive indirect effect through fodder yield per plot (0.0090) and 1000 grain weight (0.1104) at genotypic level. This trait showed positive direct effect on grain yield (0.0637) the character showed positive indirect effect through plant height (0.0143), productive tillers per plant (0.0064), panicle length (0.0096), days to 50% flowering (0.0049), days to maturity (0.0024), it showed negative indirect effect through fodder yield per plot (-0.0322) and test weight (-0.0047)at phenotypic level. In the present study we found negligible direct and indirect effects for panicles per plant. These result are in conformity with Sao *et al.* (2017)with respect to panicle per plant had positive direct effect on grain yield. Similar findings were also reported by Prakash and Vanniarajan (2015) in barnyard millet. In finger millet Bezaweletaw*et al.* (2006) reported finger number exerted the highest positive direct effect (1.212) upon grain yield per plant. It also had positive indirect effect *via* days to heading (0.208), leaf number (0.170), and the number of grains per spikelet (0.129). However, the positive direct effect of number of finger was counterbalanced by relatively high negative indirect effect *via* days to maturity (-0.703), thousand-grain weight (-0.663) and productive tillers (-0.10). Panicle length exhibited positive direct on grain yield (0.1666) at genotypic level, and positive indirect effect through productive tillers per plant (0.0545), panicles per plant (0.0663), days to 50% flowering (0.0723), days to maturity (0.0846), test weight (0.0540) and negative indirect effect through plant height (-0.0385) and fodder yield per plot (-0.0507). This character showed negative direct effect at phenotypic level for grain yield (-0.0449) and negative indirect effect through tiller per plant (-0.0132), panicles per plant (-0.0067), days to 50% flowering (-0.0210), days to maturity (-0.0210) and test weight (-0.0118). In this study negligible negative indirect effect showed for panicle length per plant and negligible positive indirect effect exhibited by plant height (0.01) and fodder per plot (0.01). These finding is conformity with John (2017) in finger millet with respect to negative direct effect of finger length on grain yield and negative indirect effect through days to 50% flowering, days to maturity, plant height, fingers per ear, fodder weight and flag leaf area. The character exhibited indirect positive effect through productive tiller per plant and test weight. These result obtained were similar to those reported by Haradari*et al.* (2012) for negative direct effect on grain yield in finger millet.

Cause effect relationship with vegetative parameters.

The character plant height showed positive direct effect on grain yield per plot at genotypic and phenotypic level (0.67 and 0.12) and positive indirect effect on grain yield through panicle per plant (0.25 and 0.03), fodder yield per plot (0.05 and 0.01). It showed negative indirect effect through productive tillers per plant (-0.20 and -0.03), panicle length (-0.16 and -0.02), days to 50% flowering (-0.45 and -0.07), days to maturity (-0.50 and -0.07) and 1000 grain weight or test weight (-0.10 and -0.02). The result were in agreement with the finding of Salini *et al.* (2010) in proso millet. Plant height exhibited high magnitude of positive direct effect on grain yield . Similar result were found by Churasiya (2014) in kodo millet; Kumar *et al.* (2014) in finger millet; Surynarayana*et al.* (2014); Prakash *et al.* (2015); Jyothasna*et al*. (2016) and John (2017) in finger millet. Days to 50% flowering behaved positive direct effect on grain yield per plot (0.23 and 0.18) and positive indirect effect through productive tillers per plant (0.08 and 0.03), panicle per plant (0.03 and 0.01), panicle length (0.10 and 0.07), days to maturity (0.18 and 0.14), fodder per plot (0.008 and 0.002), it exhibited negative indirect effect through plant height (-0.15 and -0.10) and test weight (-0.010 and -0.005). These finding was in conformity with the findings of Chaurasiya (2014) for positive direct effects of days to 50% flowering on grain yield and indirect positive effect through days to maturity (0.0012) and biological yield per plant (0.0005) and showed negative indirect effect on grain yield through 1000 grain weight(-0.0004). Similar results for positive direct effects of days to 50% flowering on grain yield were in agreement with finding of Anuradha *et al.* (2013) and Suryanarayana *et al.* (2014) in finger millet. The positive direct effect of days to 50% flowering is due to earliness to drought escape. The indirect effects are the results of increase in grain yield due to increase in panicle number, panicle length and productive tillers. Days to maturity at genotypic level exhibited positive direct effect on grin yield (0.2966) and positive indirect effect through productive tillers per plant

(0.0842), panicles per plant (0.0212), panicle length (0.1505), days to 50% flowering (0.2274), fodder yield (0.0016) and test weight (0.0728), and negative indirect effect through plant height (-0.2188). At phenotypic level this trait exhibited negative direct effect on grain yield per plant (-0.0344) and negative indirect effect through tillers per plant (-0.0096), panicles per plant (-0.0013), panicle length (-0.0161), days to 50% flowering (-0.0265), test weight (-0.0002), It showed negligible positive indirect effect on plant height (0.0223) and fodder per plot (0.0002). These similar result were reported by Chaurasiya (2014) in kodo millet. Days to maturity (-0.0157) showed negaitive direct effect on grain yield and through negative indirect effect through Days to 50% flowering (-0.0079), 1000grain weight (-0.0006). In maturity in finger millet, the negative direct effect of days maturity on grain yield was largely contributed through days to 50% flowering, panicle length, plant height, productive tillers per plants and fodder yield may be due to less vegetative growth in early and medium duration varieties. The characters also possessed positive indirect effect through flag leaf area and test weight which was less in magnitude (kumar *et al.*2016).

Cause effect relationship with yield parameters

Fodder yield per plot (kg) showed positive direct effect at genotypic and phenotypic level on grain yield per plot (kg) (0.2848 and 0.1198) and negligible indirect positive effect through plant height (0.0224 and 0.0057), days to 50% flowering (0.0105.and 0019), test weight (0.0235and 0.0051), it exhibitednegative indirect effect through productive tillers per plant (-0.0415 and -0.0131), panicles per plant (-0.0043 and -0.0067), panicle length (-0.0866 and -0.0271). Days to maturity was negative at phenotypic level (-0.0006) while positive at genotypic level (0.0002). These founding is in conformity with Sao *et al.* (2017). Fodder weightper plot exhibited direct positive effect in grain yield; Prakash *et al.*(2015). John (2017) reported direct positive effect of fodder yield on grain yield and indirect effect through days to 50% flowering and test weight in finger millet. The positive direct effect of fodder yield indicated that as the straw yield increases grain yield also increases. Test weight exhibited at genotypic level negative direct effect on grain yield (-0.3500) and negative indirect effect through panicle length (-0.1134), days to maturity (-0.0859), fodder yield per plot (-0.0288) and positive direct effect through plant height (0.0547), panicles per plant (0.0649), days to 50% flowering (0.0288). This trait exhibited at phenotypic level positive direct effect on grain yield per plot (0.0909) and positive indirect effect through productive tillers per plant (0.0395), panicle length (0.0238), days to maturity (0.0208) and fodder yield. Kumar and Gupta (2009) reported that 1000 weight exhibited positive direct effect on grain yield in finger millet; similar result were found by Shet *et al.* (2010) and Dagnachew *et al.* (2012) in finger millet; Brunda *et al.* (2015) in barnyard millet. The positive direct effect of test weight suggested that as the test weight increases grain yield also increases up to certain extent. Grain yield is the end product of interaction of component characters. Apart from correlation studies, path coefficient analysis in important to obtain information about different component characters influenceing the grain yield. In present study, the direct effect of productive tillers per plant on grain yield per plot (kg) was positive and high (0.7149 and 0.2959) which indicated the true relationship of this trait; and a direct selection will be effective. Productive tillers per plant exhibited positive indirect effect to grain yield through panicle per plant (0.0745 and 0.0298), panicle length (0.2340 and 0.0871), days to 50% flowering (0.1331 and 0.0543) days to maturity (0.2029 and 0.0823), and test weight (0.3845 and 0.1288). It can be inferred that, the direct selection of Productive tillers per plant in kodo millet lead to simultaneous indirect selection of panicles per plant, panicle length, days to 50% flowering, days to maturity and test weight.

Conclussion

The character tillers per plant, panicles per plant, days to 50% flowering, fodder yield and test weight exhibited positive direct effect on grain yield. This indicated that these characters would directly influenced the yield.

Table 2: Genotypic Path coefficient analysis of grain yield contributing character in kodo millet

S.N.	Character	Plant Height (cm)	Productive tillers/ Plant	Panicles/ Plant	Panicle Length (cm)	Days to 50% Maturity (das)	Days to Maturity (das)	Fodder Yield kg/Plot	1000 Grain Weight (g)
1	Plant Height (cm)	**0.6711**	-0.2015	0.2547	-0.1552	-0.4439	-0.4951	0.0528	-0.1049
2	Productive tillers/ Plant	-0.2146	**0.7149**	0.0745	0.2340	0.1331	0.2029	-0.1041	0.3845
3	Panicles/ Plant	-0.2259	-0.0620	**-0.5951**	-0.2367	-0.0775	-0.0425	0.0090	0.1104
4	Panicle Length (cm)	-0.0385	0.0545	0.0663	**0.1666**	0.0723	0.0846	-0.0507	0.0540
5	Days to 50% Maturity (das)	-0.1534	0.0432	0.0302	0.1006	**0.2319**	0.1778	0.0086	-0.0104
6	Days to Maturity (das)	-0.2188	0.0842	0.0212	0.1505	0.2274	**0.2966**	0.0016	0.0728
7	Fodder Yield kg/Plot	0.0224	-0.0415	-0.0043	-0.0866	0.0105	0.0015	**0.2848**	0.0235
8	1000 Grain Weight (g)	0.0547	-0.1883	0.0649	-0.1134	0.0157	-0.0859	-0.0288	**-0.3500**
9	**Grain Yield kg/Plot**	**-0.1031**	**0.4035**	**-0.0876**	**0.0597**	**0.1696**	**0.1400**	**0.1732**	**0.1798**
	Partial R^2	-0.0692	0.2885	0.0521	0.0100	0.0393	0.0415	0.0493	-0.0629

R^2 =0.3486 Residual effect = 0.8071

Table 3: Phenotypic path coefficient of grain yield contributing characters in kodo millet

S. N.	Character	Plant Height (cm)	Productive tillers/ Plant	Panicles/ Plant	Panicle Length (cm)	Days to 50% Maturity (das)	Days to Maturity (das)	Fodder Yield kg/Plot	1000 Grain Weight (g)
1	Plant Height (cm)	**0.1153**	-0.0314	0.0259	-0.0219	-0.0659	-0.0747	0.0055	-0.0164
2	Productive tillers/ Plant	-0.0807	**0.2959**	0.0298	0.0871	0.0543	0.0823	-0.0322	0.1288
3	Panicles/ Plant	0.0143	0.0064	**0.0637**	0.0096	0.0049	0.0024	-0.0056	-0.0047
4	Panicle Length (cm)	0.0085	-0.0132	-0.0067	**-0.0449**	-0.0182	-0.0210	0.0101	-0.0118
5	Days to 50% Maturity (das)	-0.1028	0.0330	0.0138	0.0729	**0.1799**	0.1383	0.0028	-0.0051
6	Days to Maturity (das)	0.0223	-0.0096	-0.0013	-0.0161	-0.0265	**-0.0344**	0.0002	-0.0079
7	Fodder Yield kg/Plot	0.0057	-0.0131	-0.0106	-0.0271	0.0019	-0.0006	**0.1198**	0.0051
8	1000 Grain Weight (g)	-0.0129	0.0395	-0.0067	0.0238	-0.0026	0.0208	0.0039	**0.0909**
9	**Grain Yield kg/Plot**	**-0.0303**	**0.3076**	**0.1079**	**0.0835**	**0.1279**	**0.1132**	**0.1044**	**0.1789**
	Partial R^2	-0.0035	0.0910	0.0069	-0.0037	0.0230	-0.0039	0.0125	0.0163

R^2 =.1385 Residual effect =.9282

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