Indian J. Genet., **58**(4): 485-493 (1998)

MULTIPLE REGRESSION EQUATION AND SELECTION FOR GRAIN AND FODDER YIELD IN *SORGHUM VULGARE*

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(Received: October 4, 1995; accepted: October 30, 1998)

ABSTRACT

With a view to formulate an index to aid breeding for high yield in forage sorghum, multiple regression analysis was carried out to estimate the contributions made by eight common independent component characters. The studies in the four environments, showed the characters: green fodder yield/plant, digestible dry matter/plant and crude protein yield/plant contributed substantially to the determination of dry matter yield/plant. Dry matter yield/plant, leaf/stem ratio and panicle weight/plant were found to be most important characters in the determination of green fodder yield/plant. Dry matter yield/plant exerted highest degree of influence to the determination of digestible dry matter/plant. Seed yield/plant influenced significantly to the determination of panicle weight/plant and vice versa was also true.

The multiple correlation coefficients *R* in each case showed a high degree of goodness of fit as indicated by as high as 72% to 99% of the variability for various dependent characters in each of the fitted regression equations. The genetic upgrading of forage productivity in combination with grain in sorghum requires the judicious combining of the forage yield and forage quality components with seed yield components as indicated by multiple regression equations.

Key words: *Sorghum vulgare*, forage sorghum, multiple correlation, standard partial regression coefficient

An important aspect of breeding in sorghum is the development of dual purpose varieties. It is desirable to have plants which have both high fodder as well as high grain yield. Both these attributes are dependent upon several components, it would be useful to study the inter-relations between some of these important characters. This has been attempted by using data from an experimental set of 21 genotypes including 15 F_1 crosses and six parents grown in four locations and conducting multiple regression analysis.

MATERIALS AND METHODS

The material consisted of six parents i.e., CSV-1, CSV-4, PC-1, PC-6, BP-53 and SPV-98 and their 15 one-way crosses making 21 entries in all. These were laid out in randomised complete block design with 4 replications in four environment viz; normal and late sowing during kharif season at IARI, New Delhi (E_1 and E_2), normal sowing at IARI Regional Research Station, Hyderabad (E3) and the following normal sowing in the following season at IARI, New Delhi (E4).

Observations on the following nine characters considered for fitting multiple regression equations were recorded on five plants each per genotype per replication.

(1) Dry matter yield (DMY)/plant (g)

(2) Green fodder yield (GFY)/plant (g)

(3) Digestible dry matter (DDM)/plant (g)

(4) Crude protein yield (CPY)/plant (g)

(5) Cutting maturity (50% flowering in days)

(6) Plant height (cm)

(7) Leaf/stem ratio (L/S ratio)

(8) Panicle weight/plant (g)

(9) Seed yield/plant (g)

Five out of these nine characters were chosen to be studied for dependence of each one of them upon the remaining eight characters to get an insight into the multiple relationships among the characters and their importance in breeding for improved grain and fodder yield.

Fitting of the multiple regression equation : The technique of multiple regression analysis as given by Snedecor & Cochran [1], was used to study relationships for each of the four environments. Since the studies were concerned mainly with working out the *relative importance* of the different characters in the determination of Y, the standard partial regression coefficients have been presented rather than the simple regression coefficient.

Testing the goodness of fit of the regression equation to the observed data was done by computing the multiple correlation coefficient [1].

RESULTS AND DISCUSSION

Character association studies have been undertaken by several workers for grain component characters or forage component characters individually [2]. However, there have been no simultaneous studies on association for these two major economic characters, namely, forage and grain yield for a response to a group of common characters for developing improved varieties of forage sorghum in combination with high seed yield. In an attempt, Rana *et al.* [3] carried out multiple regression analysis in sorghum to define plant ideotype. However, their analysis was restricted to grain yield taking only it's major component characters. Also the R^2 in their study was only 59.3%.

Preliminary nature of multiple regression analysis considering five dependent characters, namely, (1) DMY/plant, (2) GFY/plant, (3) DDM/plant, (4) Panicle weight/plant and (5) Seed yield/plant and a group of eight independent characters viz., (1) DMY/plant, (2) GFY/plant, (3) DDM/plant, (4) Crude protein yield/plant, (5) Cutting maturity (50% flowering), (6) Plant height/plant, (7) Leaf/stem ratio, (8) Panicle weight/plant and (9) Seed yield/plant revealed a very high R^2 value implying thereby that, in the determination of the dependent characters Y_i's, the independent characters X_i's have made substantial contribution ranging from 73 to 96 per cent.

The results of the multiple regression analysis in the four environments are given in Tables (1-5). For particular environment β_i the standard partial regression coefficient values are given along with R^2, or the square of multiple correlation coefficient.

Dependence of DMY/plant (g):

The characters contributing significantly to the determination of dry matter yield/plant in E1 were in the following descending order of potencies as indicated by their (β_i) values : Crude protein yield/plant, DDM/plant, GFY/plant, panicle weight/plant, leaf/stem ratio, plant height, cutting maturity (50% flowering). Green fodder yield/plant and leaf/stem ratio contributed negatively.

In E2, there was only one character i.e; digestible dry matter/plant which contributed significantly to the determination of dry matter yield/plant. It's contribution was positive and it was also most potent.

In E3, the three characters contributing significantly to the dry matter yield/plant in order of descendence were : green fodder yield/plant, crude protein yield/plant and plant height.

Table 1. Dependence of Dry Matter Yield/Plant (g)

Independent characters	Standard partial regression			
	Environments			
	E 1	E 2	E 3	E 4
GFY/Plant	–0.2078*	0.0618	0.5590**	0.3960**
DDM/Plant	0.2744*	0.6708*	0.1467	0.3646**
CPY/Plant	0.7440**	0.2783	0.2625**	0.2693*
Cutting maturity (50% Flowering-days)	0.1178*	0.0052	–0.0309	0.0390
Plant height	0.0284	0.2176	0.1869**	–0.0901
Leaf/stem Ratio	–0.1589*	0.1850	0.0705	–0.1094
Panicle wt./plant	0.1872*	0.0895	–0.1389	0.0160
Seed yield/plant	–0.0640	–0.0885	0.1260	–0.0259
R^2	0.9858	0.9493	0.9954	0.9903

* : Indicates significance at 5%; ** : Indicates significance at 1%

Green fodder yield/plant, digestible dry matter/plant and crude protein yield/plant contributed significantly to the determination of dry matter yield/plant in E4. Their potencies ranked in the same order of descendence.

It would thus appear that green fodder yield/plant, digestible dry matter/plant and crude protein yield/plant in general, contributed substantially to the determination of dry matter yield/plant.

Dependence of GFY/plant (g) :

In E1, the characters significantly contributing to green fodder yield/plant were dry matter yield/plant, crude protein yield/plant, panicle weight/plant and leaf/stem ratio in that order. Out of these, dry matter yield/plant and leaf/stem ratio were negative in their effect.

None of the characters made significant contribution to the estimation of GFY/plant in E2.

Dry matter yield/plant, plant height, panicle wt./plant and leaf/stem ratio contributed in the descending order of potencies in E3.

Table 2. Dependence of Green Fodder Yield/Plant

Independent characters	Standard partial regression			
	E 1	E 2	E 3	E 4
DMY/Plant	–1.8534*	0.2076	1.4242**	1.63
DDM/plant	0.5080	0.4811	–0.1204	–0.55
CPY/plant	1.8068**	0.1767	–3.024	–1.16
Cutting maturity (50% flowering-days)	0.2421	–0.1657	0.0823	0.02
Plant height	–0.0399	0.2353	–0.2647**	0.06
Leaf/stem ratio	–0.5126*	0.0775	–0.1322*	0.12
Panicle wt./plant	0.6289**	0.4644	0.2536*	–0.03
Seed yield/plant	–0.2573	–.2109	–0.1884	0.02
R^2	0.8734	0.8296	0.9882	0.95

* Indicates the significance at 5%; ** Indicates the significance at 1%

In E4, characters dry matter yield/plant and digestible dry matter/plant contributed significantly to the determination of GFY/plant in the descending order of potencies.

An examination of the multiple correlation coefficients (R) indicated a very good fit to green fodder yield/plant. The eight characters involved together accounted for 83% to 99% of the variability in green fodder yield/plant.

An overall study of the standard partial regression indicates that characters dry matter yield/plant, leaf/stem ratio and panicle weight/plant were the most important in the determination of green fodder yield/plant.

Dependence of DDM/plant (g)

In E1, dry matter yield/plant and cutting maturity (50% flowering) contributed significantly to the determination of digestible dry matter/plant. Dry matter yield/plant was more potent than cutting maturity (50% flowering). DMY/plant showed positive effect but the effect due to cutting maturity was negative.

In E2, dry matter yield/plant and plant height contributed significantly to the determination of DDM/plant but contribution of the latter was negative.

No character showed significant contribution to the determination of DDM/plant in E3. However, dry matter yield/plant was most potent.

Table 3. Dependence of Digestible Dry Matter/plant

Independent characters	Standard partial regression			
	Environments			
	E 1	E 2	E 3	E 4
DMY/plant	1.3402*	0.5703*	1.5101	1.9130
GFY/plant	0.2782	0.1218	–4.864	–0.6992
CPY/plant	–0.449	0.3094	0.0217	–0.3227
Cutting maturity (50% Flowering-days)	–0.3096*	0.1823	0.0165	–0.1148
Plant height	0.1222	–0.2920*	–0.2604	0.145
Leaf/stem ratio	0.2147	–0.2149	–0.0518	0.114
Panicle wt./plant	–0.2042	–0.2565	0.3100	–0.095
Seed yield/plant	0.1215	0.1757	–0.3288	0.110
R^2	0.9307	0.9569	0.9525	0.949

*Indicate significance at 5%; **Indicates significance at 1%

In E4, dry matter yield/plant and green fodder yield/plant contributed significant to the determination of DDM/plant. The contribution by dry matter yield/plant was positive but that of green fodder yield/plant was negative. The potency of DMY/plant was more than that of GFY/plant.

The variability in digestible dry matter/plant accounted by all the eight characters taken together ranged between 93% to 96%.

An examination of the partial regression coefficient indicates that dry matter yield/plant generally exerted high degree of influence to the determination of digestible dry matter/plant.

Dependence of Panicle Weight/plant (g):

In E1, the characters exerting significant influence in the determination of panicle weight/plant were: dry matter yield/plant, crude protein yield/plant, green fodder yield/plant and seed yield/plant in a descending order of potencies. Crude protein yield/plant exerted a negative influence while the other three characters showed positive values.

Seed yield/plant was the only character significantly influencing panicle weight/plant in E2. It's influence was positive.

Table 4. Dependence of Panicle Weight/Plant (g)

Independent characters	Standard partial regression			
	Environments			
	E 1	E 2	E 3	E 4
DMY/plant	1.9408*	0.2733	−1.9802	0.1103
GFY/plant	0.7310**	0.4222	1.4187*	−0.0686
DDM/plant	−0.4334	−0.9212	0.4292	−0.1252
CPY/plant	−1.6164*	0.1929	0.2473	0.0156
Cutting maturity (50% Flowering-days)	−0.2409	0.2910	−0.2167	−0.0925
Plant height	−0.0010	−0.3238	0.3641	0.3235
Leaf/stem ratio	0.3809	−0.3796	0.1577	0.1673
Seed yield/plant	0.5611**	0.7244**	0.7985**	0.9731**
R^2	0.8529	0.8451	0.9342	0.9330

*Indicates significance at 5%; **Indicates significance at 1%

In E3, green fodder yield/plant and seed yield/plant showed significant influence in the determination of panicle weight/plant.

In E4, as in the case of E2, seed yield/plant was the only character which significantly influenced the determination of panicle weight/plant. It's influence was positive.

Variability in panicle weight/plant accounted by the eight characters was from 85% to 93% as indicated by the highly significant R^2 values.

It is clear from the standard partial regression coefficients that seed yield/plant influenced significantly for the determination of panicle weight/plant.

Dependence of Seed Yield/plant (g)

Seed yield/plant was dependent significantly upon panicle weight/plant in all the four environments. The amount of variability in seed yield/plant accounted for by the eight contributing characters taken together ranged from 73% to 93% as given by the R^2 values.

Table 5. Dependence of Seed Yield/Plant (g)

Independent characters	Standard partial regression			
	Environments			
	E 1	E 2	E 3	E 4
DMY/plant	–1.2220	–0.3536	2.2117	–0.1743
GFY/plant	–0.5506	–0.2509	–1.2981	0.0341
DDM/plant	0.4749	0.8259	–0.5605	0.1423
CPY/plant	0.6643	–0.1986	–0.3518	0.0542
Cutting maturity (50% Flowering-days)	0.2457	–0.1338	0.1140	0.1217
Plant height	0.0729	0.1475	–0.5023	–0.3483
Leaf/stem ratio	–0.2007	0.3110	–0.1501	–.1896
Panicle wt./plant	1.0330**	0.9479**	0.9834**	0.9496*
R^2	0.7292	0.7973	0.9190	0.9346

*Indicates significance at 5%; **Indicates significance at 1%

The broad conclusions of this study of standard partial regression reveal that the dependent character DMY/plant was contributed substantially, in general, by GFY/plant, DDM/plant, and crude protein yield/plant. Likewise, the determination of the dependent character GFY/plant indicates the contribution of DMY/plant, leaf/stem ratio and panicle weight/plant characters.

The DDM/plant was likewise influenced generally by DMY/plant. In the case of dependent seed component characters; panicle weight/plant was influenced significantly by seed yield/plant; and seed yield/plant itself was dependent significantly on panicle weight/plant. Rana *et al.* [3] also found a significant influence of panicle branches on grain yield.

The above results indicate that the selection for two common characters such as dry matter yield/plant and panicle weight/plant would be contributing substantially for accumulating forage and seed yield, for their combined improvement, apart from the importance of the other five independent component characters such as green fodder yield/plant, digestible dry matter/plant, crude protein yield/plant, leaf/stem ratio and seed yield/plant.

REFERENCES

1. G. W. Snedecor and W. G. Cocharan. 1968. Statistical Methods. Oxford & IBH Pub. Co., New Delhi.
2. V. K. S. Rana. 1982. Genetic analysis of forage cum seed characters in Sorghum. Unpubl. Ph.D. Thesis in Botany, Agra University, Agra.
3. B. S. Rana, B. C. Barah, H. P. Binswanger and N. G. P. Rao Rao. 1984. Breeding optimum plant type in Sorghum. Indian J. Genet., **44**(3): 385-398.