Research Paper :

Correlation and path analysis in F_3 material for grain yield and grain mold resistance

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International Journal of Plant Protection, Vol. 4 No. 2 (October, 2011) : 292-297

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SUMMARY

Correlation and path analysis were carried out in 99 progenies of F_3 material derived from red x red and red x white grain crosses for gain yield and mold resistance. Correlation coefficients and path coefficients were computed among 7 yield contributing characters. There was significant high positive correlation between grain yield and 1000 grain mass (0.395), grain yield and fodder yield (0.349) and plant height and fodder yield (0.418) at both genotypic and phenotypic levels. Similarly, significant but negative correlation existed between grain yield and days to flowering (-0.239) and grain yield and days to maturity (-0.403) at both genotypic and phenotypic levels. Partitioning of yield and yield components into direct and indirect effects revealed that 1000 grain mass had the highest direct positive effect on grain yield (0.335) while days to maturity had the highest direct negative effect on grain yield (-0.432). Panicle compactness, grain hardness, glume coverage and colour were important components of grain mold resistance. Genotypes with hard grains, loose panicles, medium to long glume coverage and red and black colored glumes had low incidence of grain mold.

Patted, Vinay S., Lakkundi, Basavaraj S., Dandagi, Mohan R., Kamatar, M.Y. and Hakkalappanavar, Sangamesh S. (2011). Correlation and path analysis in F_3 material for grain yield and grain mold resistance. *Internat. J. Plant Protec.,* **4**(2): 292-297.

Key words :
Correlation, Path analysis, Grain mold, Resistance, Sorghum

Received :
March, 2011
Revised :
June, 2011
Accepted :
August, 2011

In many regions of the world where sorghum is produced, grain mold is a serious disease that reduces grain quality and tis utilization. The term grain mold is used to describe the diseased appearance of sorghum grain resulting from infection by one or more parasitic fungal species. Grain mold is most commonly caused by *Fusarium moniliforme* and *Curvularia lunata* (Esele *et al*., 1993), although many other species also cause grain mold. This disease is especially severe when grain development coincides with wet and warm weather conditions.

Sorghum grain mold is one of the most important biotic constraints to sorghum improvement and production worldwide. *Kharif* sorghum grains are usually caught in September – October rains, thus mold develops on grains and make the grain unfit for consumption. In addition, consumption of mold affected grains cause health hazards to human beings, dairy animals and poultry birds. Mold reduces the germination per cent of the affected seeds thus reduce the quality of seed and grain. Development of grain mold tolerant *Kharif* sorghum varieties is the need of the day, which helps the farmer in reducing the loss of grain quality and fetches him high market price compared to deteriorated grains due to mold attack. This reduces the cost of production by avoiding spraying of chemicals and also checks the environmental hazards.

The disease is particularly important on improved, short and medium-duration sorghum cultivars that mature during the rainy season in humid, tropical and subtropical climates. Photoperiod-sensitive cultivars that mature after the rains often escape mold infection. Sorghum cultivars with white grain pericarp are particularly more vulnerable to grain mold than those with brown and red grain pericarp. Though lot of information is available on the quantitative characters, less information is available about the inheritance of grain mold resistance as well as its association with other morphological traits. Keeping in this view, the present investigation was undertaken in segregating generation (F_3) progenies of red ×

red and red × white crosses in sorghum.

MATERIALS AND METHODS

In the present study, F_3 generation material derived from red × red and red × white crosses were used. Along with F_3 progenies, respective parents and popular checks DSV 6 (resistant), 296 B (susceptible) were studied. The experiment was laid out in medium deep black soil under rainfed condition at Sorghum Improvement Project, University of Agricultural Sciences, Dharwad during *Kharif* 2009. The Randomized Block Design was followed with two replications and each treatment was in three rows of 6 m length with inter row spacing of 45 cm and intra row spacing of 15 cm. All the recommended practices were followed to raise good crop of *Kharif* sorghum. The experiment was grown under mist formation unit to facilitate mist formation on panicles from flowering to the physiological maturity to provide high humidity (>90% RH). The mist formation unit was run for one hour thrice a day morning, afternoon and at evening. Ten panicles of uniformly flowering plants were tagged in each replication for recording grain mold infection at physiological maturity (PM) and on threshed grain (TG) using the 1-9 progressive scale where 1= no mold, 2=1-5%, 3=6-10%, 4=11-20%, 5=21-30%, 6=31-40%, 7=41-50%, 8=51-75% and 9>75% mold. Data were recorded for days to 50% flowering, days to maturity, plant height, panicle length, panicle type, glumes coverage, glumes color and grain colour, grain yield, fodder yield, 1000 grain mass and grain hardness at the appropriate time of crop growth and development. Correlation coefficient was computed and tested for significance as per the procedure given by Panse and Sukhatme (1967). Path analysis developed by Wright (1921) and Dewey and Lu (1959) was used to find out the direct and indirect effects.

RESULTS AND DISCUSSION

In the present investigation, the estimates of genotypic correlation was higher than those of phenotypic correlation for most of the traits. These higher genotypic values whenever observed are contributed to the relative stability of the genotypes (Davis *et al*., 1961 and Corson and Moll, 1962). Thus, trait with higher genetic correlation may throw light on validity of selection for those traits (Table 1). Days to flowering showed highly significant negative correlation with grain yield at genotypic level which is in agreement with earlier findings of Muppidathi *et al.* (1999) and Kenga *et al*. (2006). Negative correlation is desirable for this traits as less number of days to flower reduces the crop duration, this is helpful in terms of economic cultivation of sorghum crop. Days to maturity expressed highly significant negative correlation with grain yield. This is negative correlation helps to select the early maturing genotypes with high grain yield. A highly significant and negative association at genotypic level was found between days to maturity and fodder yield. At both phenotypic and genotypic levels, plant height exerted non-significant positive correlation with grain yield. This result confirmed the findings of Bakheit (1990), Yang and Yang (1995). Panicle length recorded the non-significant association with grain yield at genotypic level, but it had positive correlation with grain yield at both level. 1000 grain weight showed highly significant and positive correlation with grain yield at both genotypic and phenotypic levels. A highly significant and positive association at genotypic levels was found between 1000 grain weight and fodder yield and plant height. Fodder yield per plant recorded highly significant positive association with grain yield at both genotypic and phenotypic level (Table 1). This significant positive association is desirable to breed dual purpose sorghum

Table 1 : Genotypic correlation co-efficient between different traits in F_3 material of sorghum derived from red x red and red x white crosses including parents and checks

Characters	Days to flowering	Days to maturity	Plant height	Panicle length	1000 gr. wt	Fodder yield/plant	Grain yield/plant
Days to flowering	1.00	0.773**	0.106	-0.198*	0.032	-0.166	-0.239*
Days to maturity		1.00	0.053	-0.102	-0.069	-0.236*	-0.403**
Plant height			1.00	0.216*	0.281**	0.418**	0.147
Panicle length				1.00	-0.156	0.118	0.075
1000 gr. wt.					1.00	0.282**	0.395**
Fodder yield/plant						1.00	0.349**
Grain yield/plant							1.00

* and ** indicate significance of values at P=0.05 and 0.01, respectively

genotypes to meet the demand of grain and fodder. A highly significant and positive association at genotypic levels was found between fodder yield and plant height and 1000 grain weight. This association is also desirable to produce higher biomass as well as bold seeds.

In the present study, the path co-efficient analysis was carried out at both phenotypic and genotypic levels and the results are discussed below (Table 2 and 3). Even though, days to flowering had highly significant negative correlation with grain yield, it showed highly positive direct effect on grain yield at both phenotypic and genotypic levels. Days to maturity showed high negative direct and indirect effect on grain yield at both phenotypic and genotypic levels (Table 3). Hence, days to maturity may not be important criteria as that of days to flowering in selection for increased yield. Panicle length had non-significant association with grain yield. The direct effect of panicle length on grain yield was negligible, due to its negative indirect effect and non-significant association with grain yield, this trait may indirectly contribute for increased grain yield. Fodder yield per plant had highly significant association with grain yield, it showed highly positive direct effect on grain yield at both phenotypic and genotypic levels (Table 4). This result confirms the findings of Pokle *et al*. (1973). This indicates that selection can also be performed for this trait coupled with grain

Table 2 : Phenotypic correlation co-efficient between different traits in F_3 material of sorghum derived from red x red and red x white crosses including parents and checks

Characters	Days to flowering	Days to maturity	Plant height	Panicle length	1000 gr. wt	Fodder yield/plant	Grain yield/plant
Days to flowering	1.00	0.373**	0.044	-0.08	-0.006	-0.11	-0.186*
Days to maturity		1.00	0.094	-0.088	-0.01	-0.069	-0.254**
Plant height			1.00	0.156	0.255*	0.292**	0.135
Panicle length				1.00	-0.136	0.072	0.090
1000 gr. wt					1.00	0.199*	0.362**
Fodder yield/plant						1.00	0.260*
Grain yield/plant							1.00

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 3 : Direct and indirect effects on grain yield at genotypic level in F_3 material of sorghum derived from red x red and red x white crosses

Characters	Days to flowering	Days to maturity	Plant height	Panicle length	1000 gr. wt	Fodder yield/plant	Grain yield/plant
Days to flowering	0.137	-0.334	-0.004	-0.019	0.011	-0.03	-0.239*
Days to maturity	0.106	-0.432	-0.002	-0.01	-0.023	-0.042	-0.403**
Plant height	0.015	-0.023	-0.034	0.021	0.094	0.074	0.147
Panicle length	-0.027	0.044	-0.007	0.097	-0.052	0.021	0.076
1000 gr. wt	0.004	0.03	-0.009	-0.015	0.335	0.05	0.395**
Fodder yield/plant	-0.023	0.102	-0.014	0.011	0.095	0.178	0.349**

* and ** indicate significance of values at P=0.05 and 0.01, respectively Residual effect 0.5616

Table 4 : Direct and indirect effects on grain yield at phenotypic level in F_3 material of sorghum derived from red x red and red x white crosses

Characters	Days to flowering	Days to maturity	Plant height	Panicle length	1000 gr. wt	Fodder yield/plant	Grain yield/plant
Days to flowering	-0.085	-0.075	0.00	-0.008	-0.002	-0.018	-0.188*
Days to maturity	-0.032	-0.20	0.001	-0.009	-0.003	-0.011	-0.254*
Plant height	-0.004	-0.019	0.008	0.015	0.087	0.047	0.134
Panicle length	0.007	0.018	0.001	0.099	-0.046	0.011	0.09
1000 gr. wt	0.00	0.002	0.002	-0.013	0.339	0.032	0.362**
Fodder yield/plant	0.009	0.014	0.002	0.007	0.068	0.160	0.260**

* and ** indicate significance of values at P=0.05 and 0.01, respectively Residual effect 0.6586

Table 5 : Frequency distribution of field and threshed grain score for grain mold tolerances in F_3 families of sorghum derived red x red and red x white crosses

Scale	Infection (%)	Resistant or susceptible	Frequency	
			Panicle grain mould score	Threshed grain mould score
1.	No mold infection	Highly resistant	0	0
2.	1-5	Resistant	20	16
3.	6-10	Resistant	35	12
4.	11-20	Moderately resistant	16	22
5.	21-30	Moderately resistant	14	22
6.	31-40	Susceptible	5	13
7.	41-50	Susceptible	4	8
8.	51-75	Highly susceptible	4	5
9.	76 and above	Highly susceptible	1	1
		Total	99	99

yield.

Grain molds of sorghum have destructive status in recent years, particularly after the release of short duration varieties or hybrids for commercial cultivation. Among 99 red x red and red x white F_3 progenies, 55 progenies showed resistant reaction to grain mold. Those progenies were: seven of IS 25025 X IS 23585 (first, second, third, fourth, seventh, eighth and ninth progenies), six of IS 21509 X IS 24996 (first, second, third, fourth, fifth and sixth progenies), three of IS 24995 X IS 23585 (fourth, fifth and sixth progenies) nine of IS 20721 X IS 25084 (first, second, third, fourth, fifth, sixth seventh, eighth and ninth progenies), five progenies of CS 3541 X IS 1130 (second, third, fourth, fifth and seventh progenies); nine of IS 24996 X IS 23585 (first, second, fourth, fifth, sixth seventh, ninth, tenth and eleventh progenies) and six of IS 24995 X IS 1130 (one to sixth), Parents IS 25025, IS 1130, IS 23585, IS 20721, IS 24996, IS 24995, IS 20757, IS 25084, IS 25022 and DSV-6 (check) showed resistance to grain mold (Table 5). Hence, further selection may be carried out in these resistant progenies to develop resistant varieties. Grain hardness is an important component for grain mold tolerance.

Out of 99 F_3 progenies 19 progenies (19%) and 30 (30%) had partly hard and hard seeds, respectively. Progenies with hard seeds showed resistance to grain mold at both field and threshed grain these results are in accordance with Jambunathan *et al*. (1992). Hard seeds are less amenable for imbibition by continuous rains there shall be less scope for saprophytes to grown on seeds. Among 99 F_3 progenies, 6 progenies (6%), 9 progenies (9%) and 26 progenies (26%) were having very loose, loose and semi loose panicles, respectively and low incidence of grain mold was observed in these progenies (Table 6). Hence, loose panicle is one of the important component traits for grain mold tolerance. The reason for low incidence of mold in loose panicles is due to non

Table 6 : Variation between F_3 families of sorghum derived from red x red and red x white crosses for grain mold associated characters

Sr. No.	Characters	F_3 progenies	
		No. of families	Per cent families
1	**Grain hardness**		
	Very soft	15	15.15
	Soft	35	35.35
	Partly hard	30	30.30
	Hard	19	19.19
	Very hard	00	00.00
	Total	99	100.00
2	**Panicle compactness**		
	Very loose	06	6.06
	Loose	09	9.09
	Semi loose	26	26.26
	Compact	17	17.17
	Semi compact	41	41.41
	Total	99	100.00
3.	**Glume coverage**		
	Very short	00	0.00
	Short	19	19.19
	Medium	52	52.52
	Long	21	21.21
	Very long	07	7.07
	Total	99	100.00
4.	**Glume colour**		
	Black	63	63.63
	Brown	2	2.02
	Red	17	17.17
	Light red	8	8.08
	Straw	9	9.09
	Total	99	100.00

retention of moisture and air circulation. Glume length and area of coverage over the grain are related to grain mold escape as the grains are protected from exposure to rain. In present study, twenty one progenies (21%) and seven progenies (7%) had long glume coverage and very long glume coverage, respectively and were resistant to grain mold at both field and threshed grain score. The results confirm the findings of Mansuetus *et al.* (1990). Among 99 F_3 progenies 63 progenies (63%) and 17 progenies (17%) had black and red glume colour, respectively (Table 6 and 7). Low incidence of grain mold was observed in these progenies. Progenies which had red and black coloured glumes were moderately resistant to grain mold, where as progenies which had brown and straw coloured glumes were susceptible to grain mold. Black and red colored glumes contain the tannins, which inhibits the growth of saprophytic fungi and thus reduce the mold incidence. These results confirm the findings of Thakur *et al.* (2008).

Table 7 : Variation for grain characters in F_3 progenies of sorghum derived from red x red and red x white crosses

Sr. No.	Characters	F_3 progenies	
		No. of families	Per cent families
1.	**Grain size**		
	Small	15	15.15
	Medium	42	42.42
	Large	37	37.37
	Very large	05	5.05
	Total	99	100.00
2.	**Grain shape**		
	Circular	72	72.72
	Elliptic	26	26.26
	Narrow elliptic	00	0.00
	Total	98	100.00
3.	**Grain colour**		
	Red	44	44.44
	Light red	26	26.26
	Chaky white	16	13.13
	Pearly white	13	16.16
	Yellow	00	0.00
	Total	99	100.00
4.	**1000 grain weight**		
	Very low	00	0.00
	Low	48	48.48
	Medium	39	39.39
	High	12	12.12
	Very high	00	0.00
	Total	99	100.00

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