Research Article

Effect of temperature on seed setting behaviour in *rabi* sorghum (*Sorghum bicolor (*L). Moench)

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Abstract

Pollen viability is an important parameter of yield as for as interaction of temperature with seed setting is concerned. Rabi sorghum is one of the major cereal crops after rice, wheat and maize. In sorghum seed setting is affected when the flowering period coincides with minimum temperature. In this context comparison was made with pollen fertility percentage and seed setting percentage vs minimum temperature at flowering. The study revealed that the range of pollen fertility percentage was higher than the range of seed setting percentage in all the dates of sowing and temperature regimes. Narrow range of seed set % was observed in BRJ-358, BRJH-129 and R-354.Varieties showed high seed set percentage (79.3) compare to hybrids, R lines, B lines and stay green lines but mean pollen fertility was still higher than this i.e >90%. In other words, seed setting percentage is more affected by temperature at all the six dates compare to pollen fertility.

Key words: Sorghum, seed setting

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is an important food and fodder crop of the world and is considered as king of millets. Post-rainy season sorghum is cultivated in conserved moisture in black soils and sowing is generally done at favorable moisture conditions that occur after the first week of September. The sowing dates vary from location to location and year to year, and usually extend up to the end of October. Minimum temperature declines from about 20°C at sowing to 12°C at flowering and increases to 18°C during grain filling period. The post-rainy season adapted land races are photoperiod sensitive, thermo insensitive, tolerance to moisture stress and produce high biomass and possess bold and lustrous grains; however, the productivity of these land races is low.

Interaction of viable pollen production or pollen shedding with temperature was reported by Stephens and Holland as early as 1954 itself. More specifically, when minimum temperature goes below 10°C for several days during flowering, the hybrids that are otherwise male fertile show male sterility (Reddy *et al.,* 2003). Hence, seed setting ability in hybrids at low temperature is critical to the success of post-rainy season hybrids and it is necessary to understand the interrelation between pollen fertility and seed setting percentage with special reference to varying temperature during growing season of sorghum.

AICRP on *rabi* sorghum, RARS, Bijapur-586101

Materials and Methods

The present investigation focusing mainly on study of pollen fertility and seed setting behavior in *rabi* sorghum genotypes in response to varying temperature regimes was carried out during *rabi* season 2006-07 at Regional Agriculture Research Station, Bijapur, Karnataka. The experimental material consisted of 35 elite sorghum genotypes including hybrid parents (restorer and maintainer), hybrids, varieties and stay green lines. The experimental material was evaluated over six different dates of sowing. Each sowing was taken with an interval of 7-8 days, so as to adjust flowering at different temperature regimes. Recommended package of practice was followed and the crop stand

and crop growth were satisfactory in all the six environments.

Twelve quantitative characters *viz.,* plant height, days to 50% flowering, number of leaves per plant, length of the panicle, panicle weight, panicle diameter, number of primaries per panicle, number of grains per panicle, 500grain weight, grain yield per plant, seed setting percentage and pollen fertility percentage. Data collected on five individual plants of each genotype in two replications at each environment was subjected for statistical analysis.

Results and Discussion

The phenotype of a plant is the result of interaction of a large number of factors. Hence, final yield is the sum total of effects of several component factors. Therefore, it is important to know the extent and nature of interrelationship between grain yield and its contributory characters and also among themselves. The correlation coefficient helps the breeder in determining the direction and number of characters to be considered in improving the grain yield. In the present study, phenotypic and genotypic correlations were computed for various characters at all the six environments.

Comparison of character association between yield and its components across different dates of sowing:

The trait days to 50% flowering was not associated with yield and important yield components like number of primaries per panicle, number of seeds per panicle. This indicates that it is possible to develop high yielding genotypes with varying maturity period (Table 1). Number of primaries per panicle had strong positive association with seed set percentage, number of primaries per panicle and grain yield per plant. This reveals that if selection is practiced for number of primaries per panicle the grain number and ultimately grain yield could be increased. The seed setting percentage exhibited strong association with grain number per panicle and grain yield per plant at both genotypic and phenotypic levels at all the dates of sowing indicating that this is an important character that needs to be considered while development of new parental lines and varieties. Similar results were also recorded earlier by Iyanar *et al*. (2001), Veerabadhiran and Kennedy, 2001.

Interestingly pollen fertility percentage had no association with seed set percentage, number of seeds per panicle and grain yield per plant in all the dates except 3rd date. This indicates that pollen fertility may not be related to spikelet fertility. Previous reports have indicated higher pollen fertility but lower seed set (Sampath, 1964). This suggested that the two aspects of sterility i.e., pollen sterility and spikelet sterility may have distinct causes. It is also possible that, environmental factors may influence at pollen germination and pollen tube growth stages and not at the pollen production level.

Pollen fertility percentage and seed set percentage vs. minimum temperature at flowering:

In sorghum seed setting is badly affected when the flowering period coincides with minimum temperature. In this context, a comparison was made with pollen fertility percentage and seed set percentage vs minimum temperature at flowering. The study revealed that the range of pollen fertility percentage (58.6-99.7) was lower than the range of seed setting percentage (6.4-95.5) in all the dates of sowing and temperature regimes (Table 2). In other words, seed setting percentage is more affected by temperature at all the six dates compared to pollen fertility. Narrow range of seed set % was observed in BRJ-358, BRJH-129 and R-354. Varieties showed high seed set percentage (79.3) compare to hybrids, R lines, B lines and stay green lines but mean pollen fertility was still higher than this *ie* 90%.This indicates that seed set may not be entirely dependent on the pollen fertility. There could be factors other than pollen fertility influencing seed setting percentage. The pre-fertilization stages like pollen germination, pollen tube elongation might be sensitive to lower minimum temperature resulting reduced seed set. Similar observations on higher pollen fertility and lower spikelet fertility were recorded in rice by Sivasubramaniam *et al*. (1972), Sampath (1964) and Balaravi (1967). In the present study, the seed setting percentage (irrespective of sowing dates) was more than 65 as long as minimum temperature was higher than 13°C, where as seed set was drastically reduced when temperature dropped down to below 10°C. However, the genotypes exhibited differential response to the minimum temperature prevailed during flowering. Reddy *et al.* (2003) also observed that when minimum temperature goes less than 10°C, the hybrids otherwise male fertile show male sterility as evidenced by partial or complete absence of seed setting.

Comparative mean performance of maintainers (B lines), restorers (R lines), stay green lines, hybrids and varieties for different characters:

The average performance of B lines, R lines, varieties, hybrids and stay-green lines were compared to know their behavior across the dates of sowing and temperature regimes (Table 3) as these groups are distinct in their origin and pedigree. The results revealed that the average plant height of B lines was lowest (131.6 cm) followed by R lines (144.9 cm), hybrids (163.8 cm) and the varieties (190.4 cm). With respect to days to 50 percent flowering, hybrids were earliest to flower (69.6 days) followed by B lines (72.5 days), R lines (73.9 days) and varieties (76.7 days). The two traits plant height and days to flowering are considered important for successful hybrid seed production and the present material (B and R lines) appeared to be suitable and useful from this point of view. However, mean performance of genotypes for the seed set percentage, test weight, grain number per panicle was lowest in the B lines compared to R lines and other categories. This suggests that there is need to improve the existing B lines for these traits. The two stay-green lines *viz*., B35 (temperate type) and RSG03123 (derivative of temperate × tropical cross) recorded lowest mean performance for all the characters indicating their unsuitability to *rabi* season. This indicates that, while introducing stay-green trait into R16 (tropical) from B35, as well as B lines derived from tropical × temperate crosses the temperature sensitivity is introduced in tropical sorghum, the otherwise tolerant to variation in temperature. The varieties which are tropical in origin are less sensitive to change in temperature regimes. Reddy *et al.* (2003) opined that that improved cultivar derived using temperate sorghum were found to be photoperiod insensitive and temperature sensitive. Because of this temperature sensitivity their growth is reduced and development is delayed in rabi season. Therefore, improved *rabi* season cultivars (which involves temperate lines) usually to perform well in rabi season.

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Table 1 - Correlation among important traits

Characters	Dates	Correlation*	No. of primaries per panicle	Pollen futility %	Seed set %	No. of seeds per panicle	Grain yield per plant
Days to 50% flowering (D50%F)	1	P	0.18	0.54**	0.50**	0.31	0.06
		G	0.07	0.15	0.009	0.11	-0.01
	2	P	0.19	0.04	0.17	0.35*	0.33*
		G	0.14	0.06	0.11	0.32	0.29
	3	P	0.43*	0.12	0.31	0.06	0.07
		G	-0.01	0.00	0.20	0.07	-0.02
	4	P	0.20	0.45**	-0.25	0.09	-0.03
		G	0.13	0.36**	-0.16	0.06	0.001
	5	P	0.04	0.22	0.18	-0.16	-0.06
		G	0.03	0.12	0.18	-0.19	-0.06
	6	P	-0.23	0.34*	0.50**	-0.51**	-0.30
		G	-0.18	0.17	0.38*	-0.39*	-0.27
No. of primaries per panicle (NP)	1	P		0.32*	0.89**	0.74**	0.77**
		G		0.14	0.51**	0.63**	0.66**
	2	P		-0.02	0.25	0.63**	0.94**
		G		0.06	0.22	0.84**	0.66**
	3	P		0.07	1.05**	0.97**	0.99**
		G		0.05	0.34*	0.47**	0.57**
	4	P		-0.08	-0.02	0.88**	0.87**
		G		-0.09	-0.009	0.62**	0.61**
	5	P		-0.03	0.63**	0.75**	0.76**
		G		0.02	0.43**	0.54**	0.53**
	6	P		-0.04	0.04	0.97**	0.90**
		G		-0.09	0.02	0.55**	0.72**
Pollen fertility (PF)	1	P			0.58**	0.42*	0.36*
		G			0.23	0.27	0.25
	2	P			0.28	-0.10	-0.10
		G			0.19	0.01	0.01
	3	P			-0.35*	-0.72**	-0.43**
		G			-0.07	-0.27	-0.32
	4	P			-0.02	-0.19	-0.26
		G			0.07	-0.12	-0.14
	5	P			0.58**	0.25	0.06
		G			0.29**	0.07	0.05
	6	P			0.15	-0.43**	-0.35
		G			0.10	-0.18	-0.13
Seed setting (%) (SS)	1	P				0.69**	0.63**
		G				0.44**	0.39**
	2	P				0.28	0.22
		G				0.25	0.21
	3	P				0.70**	0.81**
		G				0.46**	0.53**
	4	P				0.36*	0.48*
		G				0.26	0.30
	5	P				0.50**	0.45**
		G				0.34*	0.35*
	6	P				0.10	0.11
		G				0.20	0.07
No. of seeds (NS)	1	P					0.90**
		G					0.86**

2	P	0.94**
	G	0.93**
3	P	0.98**
	G	0.73**
4	P	0.98**
	G	0.87**
5	P	0.89**
	G	0.67**
6	P	1.04**
	G	0.81**

*** G and P are genotypic and phenotypic correlation coefficients**

Table 2: Range of temperature in different mean standard weeks (MSW) at the time of sowing and flowering in different environments (sowing dates)

Sowing dates	Range of days to 50% flowering		Pollen fertility percentage		Seed set percentage		Temperature in different mean standard week													
							Minimum temperature at sowing						Minimum-Maximum temperature at flowering							
	Mean	Range	Mean	Range	Mean	Range	38	39	40	41	42	43	48	49	50	51	52	1	2	3
1st date	77.48	73.0-82.5	91.18	58.6-97.5	65.40	36.5-86.0	20.9	-	-	-	-	-	17.0-30.7	13.1-29.7	13.3-29.8	-	-	-	-	-
2nd date	72.17	65.0-80.50	93.87	85.5-98.9	74.12	31.4-92.8	-	20.8	-	-	-	-	17.0-30.7	13.1-29.7	13.3-29.8	11.1-28.7	-	-	-	--
3rd date	67.98	62.50-74.50	92.70	72.6-98.4	70.94	24.9-95.1	-	-	21.1	-	-	-	-	13.1-27-7	13.3-29.8	11.1-28.7	-	-	-	-
4th date	68.98	59.0-79.50	93.05	81.2-97.9	73.77	6.4-95.5	-	-	-	20.1	-	-	-	-	13.3-29.8	11.1-28.7	10.7-29.5	-	-	-
5th date	71.37	66.0-79.50	94.41	79.5-99.0	64.85	9.1-90.8	-	-	-	-	19.5	-	-	-	-	-	10.7-29.5	9.9-29.3	-	-
6th date	78.48	69.0-86.50	95.35	82.6-99.7	57.79	17.0-79.0	-	-	-	-	-	18.2	-	-	-	-	-	9.9-29.3	11.2-29.6	12.8-31.4

Table 3 : Comparative mean performance of maintainers, restorers, stay green lines, varieties and hybrids for different character across six dates of

Genotypes	Plant height	No. of leaves	Days to 50% flowering	Panicle weight	Panicle length	Panicle diameter	No. of primaries /panicle	Pollen fertility (%)	Seed set (%)	500 seed weight	No. of seeds/ panicle	Yield/ plant
B lines (13)												
Average	131.6	6.5	72.5	46.9	21.8	12.4	50.6	93.3	65.4	13.5	1261.6	34.2
R line (9)												
Average	144.9	7.5	73.9	54.8	18.5	13.3	52.5	94.7	69.9	15.2	1465.5	44.9
Stay green lines (2)												
Average	108.6	7.1	72.3	38.8	20.1	11.9	45.9	94.1	55.1	14.2	923.7	26.1
Varieties (4)												
Average	190.4	8.2	76.7	63.4	19.4	14.1	58.0	96.7	79.3	16.7	1530.0	49.9
Hybrids (7)												
Average	163.8	7.1	69.6	61.6	22.7	13.3	55.8	89.9	66.6	15.3	1583.5	49.4