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SORGHUMS IN THE POST-RAINY SEASON. I. EFFECT OF IRRIGATION AND DATE OF SOWING ON THE GRAIN AND STOVER YIELDS OF DIVERSE CULTIVARS†

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SUMMARY

In India, sorghum is grown during the post-rainy season on Vertisols with stored soil moisture. As water stress towards the end of the growing season is believed to be a major cause of poor yields in these crops, an experiment was carried out involving five sorghum genotypes and four sowing dates with and without irrigation.

Supplementary irrigation with 40 mm of water in the earliest sown crop increased grain yields by 24 and 26% in 1979 and 1982, respectively, while irrigation with a total of 120 mm water in the latest sown crop increased yields by 87 and 60% compared with the corresponding dryland crops. Early sowings always resulted in better stover and grain yields irrespective of irrigation treatment. Grain yields of hybrids were similar to those of the cultivars but their stover yields were less. The post-rainy season cultivar SPV 86 gave the best grain yield across sowing dates. The widely grown post-rainy season cultivar M 35-1 yielded less but produced more stover and its yields were more stable. The importance of the stability of grain and stover yields and of evaluating the materials for more than one date of sowing in selecting sorghums for the post-rainy season is discussed.

Belum V. S. Reddy, N. Seetharama y L. R. House: *Sorgos en la estación posterior a las lluvias. I. Efecto del riego y la fecha de siembra sobre rendimientos de grano y forraje de diversos cultivares.*

RESUMEN

En la India, el sorgo es cultivado durante la esación posterior a las lluvias en vertisoles (suelo rico en arcilla) con humedad almacenada en el suelo. Ya que se cree que la falta de agua hacia fines de la temporada de crecimiento es una causa principal de los bajos rendimientos, en estos cultivos se realizó un experimento implicando cinco genotipos de sorgo y cuatro fechas de siembra, regado y sin regar.

Riegos suplementarios con 40 mm de agua en el primer cultivo sembrado aumentaron el rendimiento de grano en un 24 y 26% en 1979 y 1982 respectivamente, mientras que el riego con un total de 120 mm en al último cultivo sembrado aumentó los rendimientos en un 87 y 60%, comparado con los correspondientes cultivos de secano. Las siembras tempranas siempre dieron como resultado mejores rendimientos de forraje y de grano, sin tener en cuenta el tratamiento de riego. Los rendimientos de grano de híbridos fueron similares a los de los cultivares, pero sus rendimientos de forraje resultaron ser menores. El cultivar SPV 86 de la estación posterior a de las lluvias dio el mejor rendimiento de grano para todas las fechas de siembra. El muy cultivado cultivar M 35-1 de la estación posterior a las lluvias rindió menos pero produjo más forraje, y sus rendimientos fueron estables. Se discute la importancia de la establilidad de los rendimientos de grano y de forraje y de evaluar los materiales para más de una fecha de siembra al seleccionar sorgos para la estación posterior a las lluvias.

INTRODUCTION

In India, sorghum (*Sorghum bicolor*) is primarily cultivated in two distinct seasons: June to October (rainy) and October to January (post-rainy). The

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post-rainy season crop is grown mostly on the Vertisols (over 6.5 million hectares) of the Deccan Plateau, situated between 16 and 20° N latitude and 74° and 80° E longitude. This crop is grown mostly on stored soil moisture and accounts for nearly 40% of the total area of sorghum, contributing 39% of the total sorghum grain production in India (Government of India, 1981).

The production of post-rainy season sorghum is limited by low night temperatures, receding soil moisture leading to water stress, and variations in day-length during the crop growth period (AICSIP, 1978; Reddy *et al.*, 1983).

Farmers sow sorghum on different dates across years and locations, depending upon the time the monsoon rains cease and allow land preparation. Efforts to improve the post-rainy season sorghum cultivars have not been very successful. This study was undertaken to study the effects of date of sowing and moisture stress on a range of sorghum genotypes, and to examine the implications for the breeding of cultivars for the post-rainy season.

MATERIALS AND METHODS

The experiments were carried out at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) about 25 km northwest of Hyderabad (latitude 17° 32′ N, longitude 78° 16′ E, altitude 530 m) during the post-rainy seasons of 1979 and 1982. The soil was a Vertisol. The 1982 experimental site had a silty clay loam topsoil, while the 1979 site had a loamy topsoil (Sardar Singh and Krantz, 1976).

In 1979, a split-split plot design with three replications was used. The main plots, irrigated and dryland, were arranged in randomized complete blocks. The sub-plots had crops sown on four dates, and the five sorghum genotypes were arranged in the sub-sub-plots. The genotypes used were CSH 1 (a rainy season hybrid), CSH 8R (a post-rainy season hybrid), M 35-1 (a widely grown post-rainy season cultivar), SPV 86 (a post-rainy season cultivar recently released for cultivation) and CSV 4 (a rainy season cultivar). In 1982 the irrigated and the dryland treatments were grown in separate trials placed next to each other in the same field, each using a split-plot design with four replications. Dates of sowing and genotypes were arranged in main and sub-plots, respectively, within each trial.

The four sowing dates (S1–S4) during 1979 were 17 September, 7 October, 3 November and 27 November. In 1982 they were 20 September, 7 October, 26 October and 24 November. The plot size was 27 m^2 in 1979 and 54 m^2 in 1982. The plots had a population density of approximately 90 000 plants ha^{-1} and were managed under high fertility conditions with sufficient plant protection measures to control insect pests.

At the time of sowing of the first two crops (S1 and S2) in 1979, and of all four crops in 1982, the soil water content was at field capacity except in the top layer. The S3 and S4 sowings in 1979 were given a supplementary irrigation of 60 mm to raise the soil moisture content to field capacity. In 1982, the S4

treatment received approximately 5 mm of water applied to the seedbed to ensure better seed to soil contact. Water in the irrigated treatment was applied through furrows, providing about 50 mm of water, a week after wilting of leaves was noticed at midday.

RESULTS AND DISCUSSION

The earliest planted crop received more rainfall in 1979 than in 1982 (Table 1). In both years the rainfall, daylength and temperature tended to decline as the season progressed. The magnitude of such changes with respect to time of sowing differed, however, between 1979 and 1982 (Table 1).

The effect of irrigation was greater following delayed planting. In 1979 the average grain yields of all genotypes in the irrigated treatment were 24 and 87% greater for the S1 and S4 crops, respectively, than for the corresponding dryland crops (Table 2) and in 1982 they were 26 and 60% greater for the S1 and S4 crops, respectively (Table 3). Similarly, irrigation increased stover yields by 43 (S1) and 55% (S4) in 1979, and by 41 (S1) and 100% (S4) in 1982 (Tables 4 and 5).

Grain yields declined with delay in sowing except with the S4 crop in 1982 (Tables 2 and 3). In both years, the earliest planted (S1) crop (averaged across genotypes) gave significantly higher grain yields with or without irrigation than the crops planted at other dates. Similar results were obtained by Rao (1982),

Table 1. *Meteorological parameters during the 1979 and 1982 post-rainy seasons at Patancheru for different intervals of the crop growth period*

	Crop growth period (days)	Date of sowing†							
		1979				1982			
		S1	S2	S3	S4	S1	S2	S3	S4
Total rainfall (mm)	1-30	286	65	80	3	81	63	18	0
	31-60	66	18	0	0	67	7	0	0
	61-106	17	0	0	4	0	0	0	0
Average daylength (h)‡	1-30	11.6	11.4	11.2	11.1	11.5	11.4	11.2	11.1
	31-60	11.3	11.2	11.1	11.1	11.3	11.2	11.1	11.1
	61-106	11.1	11.1	11.2	11.4	11.1	11.1	11.1	11.3
Mean daily temperature Minimum (°C)	1-30	21.5	20.3	19.4	16.0	20.1	19.8	18.4	13.6
	31-60	19.8	18.6	14.8	14.6	19.6	16.1	13.6	12.7
	61-106	16.3	14.9	15.9	17.7	13.6	12.9	13.6	17.2
Mean daily temperature Maximum (°C)	1-30	30.5	31.2	28.6	27.9	30.8	29.8	28.8	28.1
	31-60	30.1	28.4	27.7	28.5	28.7	28.3	28.1	28.6
	61-106	28.0	28.1	29.7	32.7	28.1	28.5	29.0	32.4
Average solar radiation ($MJ\ m^{-2}\ d^{-1}$)	1-30	17.1	17.8	15.9	15.9	19.5	17.2	17.5	16.3
	31-60	17.4	16.3	16.7	18.1	15.7	16.7	16.2	17.9
	61-106	16.2	17.2	18.7	20.2	16.7	17.3	18.5	20.5

† In 1979 S1 was 17 September, S2 7 October, S3 3 November and S4 27 November.
In 1982 S1 was 20 September, S2 7 October, S3 26 October and S4 24 November.
‡ Calculated from List, 1971.

Table 2. *Effect of irrigation and sowing dates (S1 to S4, see Table 1) on grain yields (t ha^{-1}) of five sorghum genotypes in 1979*

Sorghum genotype	Irrigated					Dryland				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
CSH 1	3.1	3.4	3.3	1.5	2.8	3.0	2.6	1.1	0.8	1.9
CSH 8R	3.3	3.3	2.3	1.7	2.7	2.7	2.2	1.8	0.9	1.9
M 35-1	2.4	1.7	2.4	1.6	2.0	2.3	1.7	1.3	0.7	1.5
SPV 86	3.7	2.9	3.0	1.3	2.7	2.3	2.2	1.0	0.9	1.6
CSV 4	2.9	2.5	2.8	1.0	2.3	2.1	1.7	1.4	0.6	1.4
Mean	3.1	2.8	2.8	1.4	2.5	2.5	2.1	1.3	0.8	1.7

SE of means for comparing:
Irrigations ± 0.09
Sowing dates ± 0.10
Genotypes ± 0.06
Genotypes at same dates of sowing and levels of irrigation ± 0.17

Table 3. *Effect of irrigation and sowing dates (S1 to S4, see Table 1) on sorghum grain yields (t ha^{-1}) in 1982*

Sorghum genotype	Irrigated					Dryland				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
CSH 1	4.0	3.0	1.1	3.0	2.8	3.3	2.0	1.1	1.6	2.0
CSH 8R	2.9	1.9	1.3	3.1	2.3	2.1	1.6	1.0	2.2	1.7
M 35-1	1.6	1.4	1.1	2.1	1.5	1.4	1.5	1.2	1.7	1.5
SPV 86	4.2	2.6	1.4	2.9	2.7	2.9	1.9	1.3	1.9	2.0
CSV 4	3.7	2.3	1.0	3.0	2.5	3.3	1.8	0.6	1.5	1.8
Mean	3.3	2.3	1.2	2.8	2.4	2.6	1.8	1.0	1.8	1.8

SE of mean for comparing:

	Irrigated	Dryland
Sowing dates	± 0.18	± 0.17
Genotypes	± 0.08	± 0.06
Genotypes at same date of sowing	± 0.17	± 0.12
Sowing dates with same or different genotypes	± 0.23	± 0.20

Table 4. *Effect of irrigation and sowing dates (S1 to S4, see Table 1) on sorghum stover yields (t ha^{-1}) in 1979*

Sorghum genotype	Irrigated					Dryland				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
CSH 1	5.2	7.2	4.2	2.4	4.7	3.7	2.4	1.9	1.3	2.3
CSH 8R	6.0	7.2	4.1	2.9	5.0	4.5	2.7	2.7	1.7	2.9
M 35-1	9.5	11.3	5.4	4.5	7.7	8.6	7.6	3.4	2.8	5.6
SPV 86	11.5	11.2	4.1	3.6	7.6	6.4	5.2	2.7	2.3	4.1
CSV 4	6.4	7.4	3.0	2.4	4.8	3.8	3.5	1.8	2.1	2.8
Mean	7.4	8.9	4.2	3.2	6.0	5.4	4.3	2.5	2.0	3.5

SE of means for comparing:
Irrigation ± 0.32
Sowing dates ± 0.34
Genotypes ± 0.16

Table 5. *Effect of irrigation and sowing dates (S1 to S4, see Table 1) on sorghum stover yields (t ha^{-1}) in 1982*

Sorghum genotype	Irrigated					Dryland				
	S1	S2	S3	S4	Mean	S1	S2	S3	S4	Mean
CSH 1	6.4	3.9	1.7	4.7	4.2	4.4	3.0	1.9	2.2	2.9
CSH 8R	5.3	4.2	2.4	4.6	4.1	3.9	3.1	1.9	2.7	2.9
M 35-1	8.7	6.1	2.8	8.0	6.4	7.9	5.8	2.8	3.6	5.0
SPV 86	8.2	5.5	2.8	5.4	5.5	6.2	3.6	2.0	2.6	3.6
CSV 4	7.1	7.4	2.1	3.7	5.1	4.9	5.2	2.0	2.2	3.5
Mean	7.1	5.4	2.4	5.3	5.1	5.5	4.1	2.1	2.6	3.6

SE of means for comparing:

	Irrigated	Dryland
Sowing dates	± 0.25	± 0.26
Genotypes	± 0.21	± 0.19
Genotypes at same date of sowing	± 0.41	± 0.38
Sowing dates with same or different genotypes	± 0.44	± 0.43

Rao *et al.* (1977) and AICSIP (1975; 1976). The pattern of stover yields was similar to that of the grain yields (Tables 4 and 5) except for the S2 crop in 1979.

The higher grain yields from S4 than from S3 in 1982 (Table 3) may have been due to more favourable conditions at grain filling, resulting in a higher harvest index and improved seed size (ICRISAT, 1984). Although the late sown crop of CSH 8R yielded more grain than the early sown crops in 1982 (Table 3), the reverse was the case with fodder yield (Table 5) as the vegetative stage coincided with the coolest period of the season (Table 1).

Genotype differences and genotype X date of sowing effects were highly significant for both the traits (Tables 2, 3, 4 and 5) indicating that the response to delayed sowing differed significantly with genotype.

The rainy season hybrid CSH 1 yielded more grain than the post-rainy season hybrid CSH 8R at S2 and S3 in 1979 and at S1 and S2 in 1982, but CSH 8R yielded more stover. However, both hybrids yielded significantly less stover than the post-rainy season cultivars. CSH 1 grown under dryland conditions yielded more grain than SPV 86 in 1979. Thus, when both the stover and grain yields are considered, the hybrids were not superior to the post-rainy season cultivars. Of the two post-rainy season cultivars, SPV 86 yielded more grain while M 35-1 produced more stover. CSV 4, the rainy season cultivar, was not as good as SPV 86 for either stover or grain yields.

The significant interaction between date of sowing and genotypes indicates the need to evaluate material for post-rainy season adaptation by sowing on more than one date to include the range of farmers' sowing dates. High and consistent stover yield and stability of grain yield across different sowing dates, as shown by the most popular cultivar M 35-1, may be important in breeding sorghums for the post-rainy season.

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