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INTERACTIVE EFFECTS OF FERTILITY LEVELS AND GENOTYPES ON PRODUCTION POTENTIAL, QUALITY ESTIMATION AND DISEASE INCIDENCE OF FORAGE SORGHUM

MANINDER KAUR*, HARPREET KAUR OBEROI AND ASHLESHA

Forages, Millets and Nutrition Section,
Department of Plant Breeding and Genetics
PAU, Ludhiana-141 004 (Punjab), India
**(e-mail : manindersindhu@pau.edu)*
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SUMMARY

A study was conducted during *kharif* season of 2020 on sandy loam soils of forage research farm of PAU, Ludhiana to study the interactive effects of different fertility levels {control, 50:10:12.5, 100:20:25 (recommended dose of fertilizers) and 150:30:37.5 kg N: P_2O_5: K_2O per ha} and five genotypes (SPV 2584, SPV 2587, SPV 2593, CSV 21F and CSV 30F) on growth, yield, quality and disease incidence of single cut forage sorghum. The experiment was laid out in Randomized Complete Block Design (RCBD), using three replications. It was revealed from the results that SPV 2584 owing to its profused tillering gave highest green fodder yield to the tune of 76.4% over the check genotype CSV 30F. The genotypes SPV 2593 and CSV 21F remained statistically at par with SPV 2584 with regards to green fodder productivity. The genotype SPV 2584 also remained superior in terms of quality of green fodder recording highest value of crude protein content (6.36%) and lowest value of hydrocyanic acid (44.7%) over other genotypes. The effect of fertility levels was found to be significant upto 100:20:25 kg NPK/ha giving 21.6 and 26.6% increase in green fodder and dry matter yield, respectively with 50 percent increase in fertility level. The quality of forage sorghum increased with increase in fertility level with corresponding increase in HCN also. The effect of fertility and genotypes on disease severity was found to be significant and highest disease reduction of anthracnose (35.1%) was recorded with application of 100:20:25 kg NPK/ha.

Keywords : Growth, genotypes**,** fertility, sorghum, anthracnose

Sorghum [*Sorghum bicolor* (L.) Moench] is an important cereal crop grown worldwide ranking fifth after wheat, rice, maize and barley (Khalil, 2008). Primarily, a crop of hot and dry regions, it is grown as a preferred crop for food and feed in the dry climates of Africa, India, Pakistan, China and the Southern US (Algarswamy and Chandra, 1998). Forage sorghum genotypes exhibit faster growth and produce highly palatable and nutritious green fodder which could be utilized as silage and hay besides as fresh fodder (Ahmed *et al.,* 2019). In forage sorghum improvement, the breeding objectives are to improve sorghum genotypes for their yield, quality and tolerance to diseases. Besides, genetic factor, adequate fertilization plays a vital role in increasing the fodder production. Fertilization is important for the growth and development of the crops and it can also be an important factor in disease control (Agrios, 2005). All the essential nutrients are known to affect disease severity (Huber and Graham, 1999). Although, plant disease resistance and tolerance are genetically controlled, but these are affected by the environment especially the nutrient deficiencies or toxicities (Krauss, 1999). Hence, the use of fertilizers together with suitable genotypes can affect the disease incidence (Oborn *et al.,* 2003). Various foliar diseases like anthracnose, gray leaf spot and zonate leaf spot are the key impediments in the successful cultivation of sorghum. The impact of foliar diseases not only hampers the quality and nutritive value of fodder as well as grain yield (Pande *et al.,* 2003), but also results in the reduction of income from fodder sale and milk production (Rama *et al.,* 2000). Yield losses as high as 50% has been reported due to foliar diseases with prevailing high temperatures and wet weather (Tesso, 2012). Among foliar diseases, anthracnose is the most prominent and damaging on forage and grain sorghum (Thakur and Mathur, 2000). Sorghum anthracnose, incited by *Colletotrichum sublineolum* Hann. Kabát et Bub. (syn. *C. graminicola* (Ces.) G.W. Wilson) is one of the key limiting factors in all sorghum growing areas (Marley *et al.,* 2001). Therefore, the present study was planned to identify suitable forage sorghum genotypes for higher fodder production at different levels of fertility and their interactive effect on incidence of diseases in forage sorghum.

MATERIALS AND METHODS

Description of the experimental site

The field experiment was carried out the during the rainy season of 2020 at PAU, Ludhiana (30°54' N latitude and 75°48' E longitude with an altitude of 247 metres above mean sea level) in the central plain region of Punjab state under Trans-Gangetic agro-climatic zone of India. The climate of Ludhiana is sub-tropical and semi-arid. The average annual rainfall is 705 mm. Ludhiana soil is classified as Inceptisols, well drained sandy loam with an average pH of 7.8. The experimental crop received optimum weather conditions throughout the growing season. The weather data prevailing during the crop season is presented in Fig. 1.

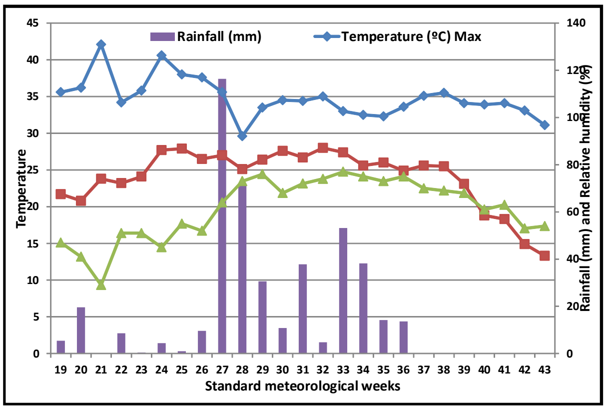

Fig. 1. Weekly weather data prevailing during the crop growing season.

Experimental design and methodology

A factorial randomized complete block design was used to evaluate the performance of single cut forage sorghum genotypes for growth, yield, quality and disease incidence under different fertility regimes. The treatments thus comprised combinations of five forage sorghum genotypes (SPV 2584, SPV 2587, SPV 2593, CSV 21F and CSV 30F) and four fertility levels (control, 50:10:12.5, 100:20:25 and 150:30:37.5 kg N: P_2O_5: K_2O per ha) and each treatment was replicated thrice. Sowing was done in the first week of July and seeds were planted in opened furrows spaced 25 cm apart using a seed rate of 62.5 kg per ha. As per the treatments, half dose of nitrogen through urea and full dose of phosphorus in the form of single super phosphate and potassium as muriate of potash were applied as basal. The remaining half dose of nitrogen was applied at 35 days after sowing. Two hand weedings were done at 20 and 40 days after sowing to keep the crop weed free. Other management practices were adopted as per recommendations of sorghum crop.

Data collection

The crop was harvested at 50% flowering stage. The data on growth characters *viz.* plant height, number of tillers, leaf: stem ratio, green fodder and dry matter were recorded at the time of harvest. Additional plant samples were collected at harvest and analyzed for quality parameters by following standard procedures.

Disease severity in each treatment was visually assessed to rate the leaf spot severity on sorghum plants. The disease scoring was done 30 days after sowing and at the time of harvesting. The severities of anthracnose, zonate leaf spot and gray leaf spot diseases were recorded using 1-9 rating scale of Ngugi *et al.* (2000) and converted to percent disease severity index (DSI) using the given formula:

$$\text{Disease severity index (\%)} = \frac{\text{Sum of all ratings}}{\text{total number of plants observed} \times \text{maximum rating scale}} \times 100$$

Statistical Analysis

The data were analyzed according to Fisher's technique of Analysis of Variance (ANOVA) (Gomez and Gomez, 1984). The differences between treatments were tested by the least significant difference at a 5% level of probability when ANOVA was significant.

RESULTS AND DISCUSSION

Growth and yield studies

The results of the study revealed significant variation (P≥0.05) among genotypes for plant height, number of tillers, days to flowering, leaf stem ratio, green fodder and dry matter yield (Table 1). The genotype CSV 21F recorded significantly taller plants (226.0 cm) being closely followed by the genotype SPV 2587. With regard to tillering, SPV 2584 was found to be the most profusely tillered genotype with maximum number of tillers per ha (1012.5 thousand) but it remained at par with genotypes SPV 2593 (910.0 thousand) and CSV 21F (887.5 thousand). Maximum numbers of days to flowering were taken by the genotypes SPV 2593 and SPV 2584. Highest green fodder yield was obtained by the genotype SPV 2584 (48.52 t/ha) which was 76.4% higher than the check genotype CSV 30F. The green fodder yield of genotypes SPV 2593 and CSV 21F remained at par with that of SPV 2584. A similar trend was noticed in the dry matter yield. Although the plants of SPV 2584 were not very tall compared to SPV 2593 and CSV 21 F but owing to its profused tillering habit, and longer duration of vegetative growth the genotype SPV 2584 accumulated maximum dry matter and hence green fodder yield. The check genotype CSV 30F remained inferior compared to rest of the genotypes and recorded the lowest values for different parameters, dry matter and green fodder yield. The differences in the genetic makeup might be responsible for the differential behavior of these genotypes (Meena *et al.,* 2012). Previously, other workers have also noticed the variation among the forage sorghum genotypes for forage yield as well as growth characteristics (Oberoi and Kaur, 2020; Satpal *et al.,* 2016 & 2020).

Besides, production of higher quantities of herbage yield, quality of forage is an important aspect from the context of livestock production. Good quality forage is the one which is capable to supply the animal's nutrient requirements. Hence, the chemical composition, digestibility of the nutrients and the acceptability of the forage by the livestock are all very important aspects besides fodder yield. A perusal of the data in Table 2 reveals that there was significant variation among the genotypes for *in-vitro* dry matter digestibility, crude protein and hydrocyanic acid content. While the genotype CSV 30F had the highest IVDMD but on account of its lower dry matter production, its digestible dry matter was significantly lower than all other genotypes. SPV 2584 was the genotype containing significantly highest content of crude protein and hence the highest crude protein yields. It also remained superior over other genotypes with regard to the presence of anti-quality component *i.e.* HCN. It had the lowest value of 44.7% for HCN followed by SPV 2593 (46.8%). Significantly highest value of HCN (67.7%) was found in the genotype CSV 30F. This is in contrast with the findings of Rana *et al.* (2012) who reported no effect of different forage sorghum genotypes on the forage quality. However, like the results of the present study, significant differences among the genotypes for forage quality were reported by Singh *et al.* (2019).

The data in Table 1 shows that the effect of different fertility levels on the growth and yield of forage sorghum was statistically significant. Plant height and numbers of tillers were found to increase consistently with increase in fertility levels. Application of 150:30:37.5 kg NPK/ha showed taller plants than application of 100:20:25 kg NPK/ha although the differences were statistically at par. The highest number of tillers per ha (924.0 thousand) were obtained with application of 150:30:37.5 kg NPK/ha, however different fertility levels failed to exhibit any significant variation with respect to tillers. The initiation of flowering was found to get extended with increase in fertility level and highest number of days to 50%

TABLE 1

Effect of different treatments on yield and yield attributes of forage sorghum

Treatments	Plant height (cm)	Plant stand/ plot	Days to 50% flowering	L:S	Green fodder yield (t/ha)	Dry matter yield (t/ha)
Genotypes						
SPV 2584	210.0	1012.5	80.6	0.18	48.52	16.07
SPV 2587	225.9	697.5	77.4	0.30	38.98	13.26
SPV 2593	217.5	910.0	84.8	0.21	45.57	13.27
CSV 21F	226.0	887.5	73.4	0.17	45.68	15.34
CSV 30F	198.9	717.5	75.8	0.29	27.50	8.48
CD (P=0.05)	15.5	223.9	1.8	0.04	4.66	1.63
Fertility levels (kg NPK/ha)						
Control	181.1	780.0	76.3	0.34	29.55	9.28
50:10:12.5	216.8	798.0	77.2	0.21	38.36	12.32
100:20:25	226.6	878.0	78.8	0.20	46.64	15.60
150:30:37.5	238.1	924.0	81.2	0.18	50.45	15.95
CD (P=0.05)	22.5	NS	2.8	0.03	7.87	2.65

TABLE 2
Effect of different treatments on proximate analysis of forage sorghum

Treatments	IVDMD (%)	Digestible dry matter yield (q/ha)	N (%)	Crop N uptake (t/ha)	CP (%)	Crude protein yield (t/ha)	HCN (ppm)
Genotypes							
SPV 2584	45.7	7.43	1.02	0.17	6.36	1.04	44.7
SPV 2587	45.3	6.05	0.86	0.12	5.39	0.73	52.8
SPV 2593	45.1	5.95	0.87	0.12	5.44	0.73	46.8
CSV 21F	46.4	7.14	0.80	0.12	4.99	0.77	58.4
CSV 30F	49.7	4.24	0.87	0.08	5.46	0.47	67.7
CD (P=0.05)	3.2	0.73	0.04	0.02	0.24	0.11	9.7
Fertility levels (kg NPK/ha)							
Control	43.7	4.04	0.78	0.07	4.88	0.45	34.9
50:10:12.5	46.5	5.66	0.87	0.11	5.43	0.67	47.5
100:20:25	48.0	7.44	0.91	0.14	5.67	0.89	65.5
150:30:37.5	47.4	7.53	0.98	0.16	6.13	0.98	68.4
CD (P=0.05)	2.7	1.68	0.07	0.03	0.41	0.17	11.3

flowering was taken by the crop when fertilized with the highest level of fertility. There was reduction in leaf stem ratio values with increase in fertility levels. This might be due to more increase in stem weight as evident from the increase in plant height with increasing fertility than the corresponding increase in the leaf weight. The effect of fertility levels on green fodder and dry matter yield was significant upto 100:20:25 kg NPK/ha. There was a commendable increase of 21.6 and 26.6% in green fodder and dry matter yield, respectively with 50 kg increase in nitrogen application upto 100:20:25 kg NPK/ha. The quality of forage sorghum as evident from a perusal of Table 2 was found to improve with increase in fertility level. The IVDMD and crude protein content was highest with application of 150:30:37.5 kg NPK/ha. However, there was also a steady increase in the HCN content with increasing fertility which is not a desirable character. Similarly, Singh *et al* (2017) found an improvement in quality parameters of single cut forage sorghum with increasing fertilization and also reported corresponding increase in HCN values. In contrast to these findings, Rana *et al.* (2012) reported that the crude protein and IVDMD of forage sorghum remained unaffected due to different fertility treatments.

Disease incidence studies

Five genotypes tested at four fertilizer levels significantly showed the varied disease severities of anthracnose infecting sorghum crop (Table 3). The genotypes SPV 2584 and CSV 21F showed least disease severities of 22.5 and 23.0%, respectively with 100:10:12.5 kg NPK/ha application followed by SPV 2587 that showed 24.5% severity. The two factor analysis showed highly significant effects of fertilizers, genotypes and the interaction, on anthracnose severity. Anthracnose severity was highly significantly decreased with 50:10:12.5 and 100:20:25 kg NPK/ha (Table 3). Lowest disease severity (24.2%) was found in response to 100:20:25 kg NPK/ha, but with increasing fertilizer application disease severity increased again, reaching

TABLE 3
Interactive effect of fertility levels and genotypes on disease severity (%) of sorghum anthracnose

Fertility levels	Genotypes						Disease Control (%)
	SPV2584	SPV2587	SPV2593	CSV 21F	CSV 30F	Mean	
			Disease severity (%)				
50:10:12.5	30.5	28.5	35.0	30.5	29.5	30.8	18.1
100:20:25	22.5	24.5	26.5	23.0	25.5	24.4	35.1
150:30:37.5	32.5	31.0	30.0	27.5	25.0	29.2	22.3
Control	38.5	36.0	41.0	37.0	35.5	37.6	

CD (P=0.05) Fertility levels: 1.05
Genotype: 1.18
Interaction: 2.35

29.2% disease severity at 150:30:37.5 kg NPK/ha but lower than control (37.6%). In response to increasing rate of fertilizer from control to 50:10:12.5 kg NPK/ha, 18.1% reduction in disease severity was recorded. Likewise, further increase in rate of fertilizer to 100:20:25 kg NPK/ha provided 35.1% disease control over unfertilized control. Whereas, increase in fertilizer dose to 150:30:37.5 kg NPK/ha provided only 22.3% reduction in anthracnose severity.

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