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Effect of inter row spacing and fertilizer levels on crop growth, seed yield and seed quality of perennial fodder sorghum cv. CoFS-29

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Abstract
A field experiment was conducted at main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* 2013 and 2014 to investigate the effect of inter row spacing and fertilizer levels on growth, seed yield and seed quality of perennial fodder sorghum (*cv*. CoFS-29). This experiment was comprised of three inter row spacing *viz.,* 30, 45 and 60 cm and four fertilizer levels *viz.* 100:40:40, 100:60:40, 150:40:40 and 150:60:40 kg NPK/ha in split plot design with three replications. The pooled results showed that wider spacing row of 60 cm produced significantly more number of tillers/plant (11.29) and leaves/plant (72.54) at harvest, higher leaf area/plant (15862 cm^2) and leaf chlorophyll content (SPAD value, 39.03) at 90 DAS and maximum panicle length (51.62 cm), number of panicles/ plant (12.02), higher seed yield/plant (15.29 g), 1000 seed weight (6.57 g), seed germination (40.83%) and seedling vigour index (1120). Whereas, plant height (200.0 cm), seed yield/ha (657.6 kg) and dry fodder yield/ha (126.7q) was higher in narrow spacing of 30 cm. Further seed yield and its attributes like plant height (202.5 cm), number of tillers/plant (11.52), leaves/plant (73.72), leaf area/plant (16244 cm^2), leaf chlorophyll content (SPAD value, 39.61), panicle length (52.64 cm), panicles/plant (11.44), seed yield/plant (14.21 g), seed yield/ha (641.6 kg) and dry fodder yield/ha (125.6 q) were observed significantly higher in plots fertilized with 150:60:40 kg NPK/ha as compared to other fertilizer levels. In general, seed quality improved significantly with increased row spacing, but fertilizer level had little effect on seed quality. However, the interaction of 30 cm row spacing and 150:60:40 kg NPK/ha shown higher seed yield/ha (671.0 kg) as compared to other interactions.

Keywords: Fertilizer levels, Fodder sorghum, Inter row spacing, Seed germination, Seed yield

Introduction

The importance of sorghum as a commercial forage crop is growing in many regions of the world due to its high productivity and efficient utilization of water even under drought conditions. In India, it is principally grown as an important *Rabi* crop since it is highly palatable and digestible as for as the nutritional quality is concerned. The present feed and fodder production can meet only 48 per cent of the livestock requirement. This deficit may be due to non-availability of quality seeds of improved forage varieties and lack of improved cultivation techniques for enhancing the average commercial forage and seed yields. Fertilizer is the most critical input required for intensive cultivation of fodder sorghum crop and its profitability depends mainly on agronomic practices and input management (Siddique, 1989; Raheja, 1996). Providing differential plant geometry may alter the plant canopy architecture affecting light interception and carbon dioxide assimilation and ultimately result in variable seed yield and quality. Therefore, the appropriate fertilizer input and ideal planting geometry is necessary for getting not only higher seed yield but also high quality seeds. Keeping in view the above the present investigation was carried out to study the effect of inter row spacing and fertilizer levels on growth, seed yield and seed quality of CoFS-29 perennial fodder sorghum.

Materials and Methods

Experimental site and design: The field experiment was conducted during *kharif* 2013 and 2014 at main agricultural research station, University of Agricultural Sciences, Dharwad. The soil of the experimental site was medium deep black with medium fertility status. The experiment was carried out in split plot design with three replications. Total 12 treatment combinations involving three inter row spacing as main plot *viz.*, 30 cm (S_1), 45

cm (S_2) and 60 cm (S_3) and four fertilizer levels as sub plot *viz.,* 100:40:40 NPK/ha (F_1), 100:60:40 NPK/ha (F_2), 150:40:40 NPK/ha (F_3) and 150:60:40 NPK/ha (F_4). Seeds of multicut perennial fodder sorghum *cv*. CoFS-29 was procured from the Indian Grassland and Fodder Research Institute (IGFRI), southern regional research station, Dharwad and sown by hand dibbling 2-3 seeds per hill at 1 to 2 cm deep, as per the treatments. Well decomposed FYM @ 10 t ha^{-1} was incorporated three weeks prior to sowing of the crop during both the seasons. The calculated quantities of fertilizers were applied as per treatments in two splits using urea, single super phosphate and muriate of potash. The half dose of N and entire dose of P_2O_5 and potash were applied at the time of sowing and the remaining half dose of N was applied to soil at 30 days after sowing (DAS). Furadon 3G granules @ 10 kg per hectare were also applied to prevent shoot fly incidence. During the course of experimentation, three numbers of hand weeding at 20, 45 and 65 days after sowing and inter-cultivation operations at 25, 35 and 45 days after sowing were attended to keep the plots free from weeds. The crop was provided with protective irrigations looking into the critical moisture condition of the soil. All the other crop management practices were followed as per recommended package of practices. The crop was harvested manually on attainment of physiological maturity when the panicles turned straw colour from net plot area.

Observations and data analysis: The observations on growth parameters *viz.,* plant height, number of tillers per plant, leaf area, leaf chlorophyll content (SPAD value) were recorded at 30, 60, 90 DAS and at harvest stage. Observations on yield parameters *viz.,* panicle length, number of panicle per plant, seed yield per plant, seed yield per hectare and dry fodder yield per hectare were recorded after physiological maturity of the crop. The seed quality parameters like germination and seedling vigour index was assessed for each treatment in four replications of 100 seeds as per ISTA procedure (Anonymous, 2014). The data collected in respect of various parameters on plant growth, seed yield and seed quality was analyzed statistically as described by Gomez and Gomez (1984).

Results and Discussion

Influence of spacing and fertilizer levels on growth parameters: The results of the pooled analysis revealed marked and consistent variations for yield and its attributing components at different crop growth stage during 2012-13 and 2013-14 years of experiments. Among the different inter row spacing, the wider row spacing of 60 cm recorded significantly higher number of leaves per plant (72.54), tillers per plant (11.29), leaf area (15862 cm^2), leaf chlorophyll content (39.03), panicle length (51.62 cm), number of panicles per plant (12.02) and seed yield per plant (15.29 g) as compared to other row spacing treatments (Table 1-3). The increased growth parameters noticed in the wider spacing might be attributed to less plant population per unit area, less competition and more space availability which resulted in the more horizontal plant spread during grand growth period due to adequate availability and use of nutrients, moisture and solar energy unlike those grown at narrow inter row spacing which recorded lower values. In contrary to this, the plant height was significantly higher in narrow row spacing of 30 cm (200.0 cm) as compared to 45 cm (196.2 cm) and 60 cm (192.8 cm) (Table 1). The significant increase in plant height at narrow inter row spacing (30 cm) might be due to its higher plant population (3,33,333 plants) per hectare and it might have produced the weak, lanky and taller plants and resulted in more vertical growth and less plant canopy area for want of adequate space, light, nutrients, moisture *etc.* Whereas, those grown in the wider inter row spacing of 60 cm were shorter in height and produced more horizontal growth and plant canopy area due to less plant population (1,66,666 plants/ha) and less competition between the plants . These results were in agreement with the earlier findings in buffel grass (Kumar *et al.*, 2005), and fodder sorghum (Ahmad *et al.*, 2007; Manjunatha *et al.*, 2013).

Influence of spacing and fertilizer levels on yield parameters: Seed and dry fodder yields were significantly higher in intra row spacing of 30 cm (657.6 kg/ha and 126.7 q/ha, respectively) as compared to 45 and 60 cm row spacing (Table 4). On an average, it recorded about 22% more seed yield and 10% more dry fodder yield over 60 cm row spacing and it might be related to 50% more plant population (3,33,333 plants/ ha) per unit area noticed in the narrow inter row spacing despite showing less yield components compared to the wider row spacing (1,66,666 plants/ha). These results were supported by the findings of Hada *et al.* (2016) in fodder maize.

The effect of fertilizer levels was found to be significant for seed yield and yield attributing parameters and quality components over inter row spacing in the pooled data as well as during 2013-14 and 2014-15 experiments at different crop growth stages. The yield attributing param-

-eters like plant height, number of tillers per plant, leaves per plant, leaf area, leaf chlorophyll content, panicle length, number of panicles per plant and seed yield per plant were significantly higher in crop supplied with higher fertilizer level of 150:60:40 kg NPK kg/ha (202.5 cm, 11.52, 73.72, 16244 cm^2, 39.61, 52.64 cm, 11.44 and 14.21 g, respectively) as against recommended dosage of 100:40:40 kg NPK per ha (190.4 cm, 10.30, 67.79, 14380 cm^2, 36.87, 47.27 cm, 10.86 and 13.18 g, respectively) in pooled analysis (Table 1-3). Similar results with respect

Table 1. Effect of inter row spacing and fertilizer levels on plant height and number of leaves at different growth stages of CoFS-29

Treatment	Plant height (cm)						Number of leaves per plant					
	60 DAS*			At harvest			60 DAS			At harvest		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Inter row spacing (S)												
S_1 : 30 cm	125.8	128.2	127.0	198.9	201.0	200.0	39.88	41.40	40.64	68.45	69.37	68.91
S_2 : 45 cm	123.5	125.4	124.5	194.8	197.6	196.2	42.05	43.63	42.84	70.33	71.27	70.80
S_3 : 60 cm	121.0	123.1	122.1	191.8	193.7	192.8	44.48	45.93	45.21	72.13	72.95	72.54
S.Em±	0.2	0.6	0.3	1.1	0.9	0.9	0.29	0.26	0.14	0.29	0.19	0.16
C.D. (P=0.05)	0.8	2.2	1.4	4.2	3.7	3.5	1.15	1.03	0.54	1.15	0.76	0.63
Fertilizer levels (F)												
F_1 : 100:40:40	119.0	121.1	120.0	189.5	191.3	190.4	38.62	39.80	39.21	67.31	68.27	67.79
F_2 : 100:60:40	120.1	122.5	121.3	190.8	192.9	191.8	39.56	40.78	40.17	68.11	68.98	68.54
F_3 : 150:40:40	126.8	128.6	127.7	199.2	201.9	200.5	44.69	46.47	45.58	72.53	73.36	72.94
F_4 : 150:60:40	128.0	130.1	129.0	201.3	203.8	202.5	45.69	47.58	46.63	73.27	74.18	73.72
S.Em±	0.9	0.6	0.4	1.8	0.9	0.8	0.64	0.63	0.44	0.64	0.79	0.61
C.D. (P=0.05)	2.5	1.9	1.3	5.4	2.6	2.3	1.89	1.86	1.30	1.89	2.34	1.80
Interactions (S x F)												
S.Em±	1.3	1.1	0.7	2.9	1.6	1.5	1.00	0.97	0.67	1.00	1.20	0.92
C.D. (P=0.05)	NS**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*DAS: Days after sowing **NS: Non significant

Table 2. Effect of inter row spacing and fertilizer levels on number of tillers and leaf area at different growth stages of CoFS-29

Treatment	Number of tillers per plant						Leaf area (cm^2/plant)					
	60 DAS*			At harvest			60 DAS			At harvest		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Inter row spacing (S)												
S_1 : 30 cm	8.77	9.05	8.91	10.35	10.72	10.53	6881	7253	7067	14580	14918	14749
S_2 : 45 cm	9.15	9.45	9.30	10.67	11.12	10.89	7377	7777	7577	15135	15473	15304
S_3 : 60 cm	9.45	9.72	9.58	11.02	11.57	11.29	7885	8266	8076	15690	16033	15862
S.Em±	0.06	0.05	0.03	0.13	0.10	0.07	67	68	44	87	68	64
C.D. (P=0.05)	0.24	0.20	0.14	0.49	0.37	0.29	262	268	175	342	266	253
Fertilizer levels (F)												
F_1 : 100:40:40	8.62	8.82	8.72	10.13	10.47	10.30	6601	6939	6770	14216	14545	14380
F_2 : 100:60:40	8.73	8.93	8.83	10.29	10.60	10.44	6804	7095	6949	14437	14759	14598
F_3 : 150:40:40	9.51	9.84	9.68	11.07	11.64	11.36	7923	8388	8156	15831	16164	15998
F_4 : 150:60:40	9.62	10.02	9.82	11.22	11.82	11.52	8196	8639	8417	16056	16431	16244
S.Em±	0.13	0.12	0.11	0.16	0.15	0.11	164	160	140	206	257	217
C.D. (P=0.05)	0.40	0.37	0.32	0.47	0.45	0.34	486	476	416	613	762	645
Interactions (S x F)												
S.Em±	0.21	0.19	0.17	0.27	0.25	0.19	254	250	215	321	391	332
C.D. (P=0.05)	NS**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*DAS: Days after sowing **NS: Non significant

to yield attributing parameters were also reported in pearl millet (Kumawat *et al.*, 2016), oats (Singh *et al.*, 2005) and perennial fodder sorghum (Manjunatha *et al.*, 2013; Rana *et al.,* 2013). Significant difference was also observed on seed yield and dry fodder yield per hectare due to fertilizer levels. On an average, the plants grown at 150:60:40 kg NPK per hectare out yielded by showing 13.75% (641.6 kg/ha) more seed yield and 8.08% (125.6 q/ha) more dry fodder yield as against those at 100:40:40 kg NPK per hectare (564.0 kg/ha and 116.2 q/ha) (Table 4). The marked increase in seed yield per plant and hectare noticed in the higher fertilizer level might be

Table 3. Effect of inter row spacing and fertilizer levels on leaf chlorophyll content, panicle length and number of panicles of CoFS-29

Treatment	Chlorophyll content (SPAD value)						Panicle length (cm)			Number of panicles per plant		
	60 DAS*			At harvest								
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Inter row spacing (S)												
S_1 : 30 cm	45.54	45.79	45.67	37.02	37.89	37.46	47.98	48.50	48.24	10.13	10.55	10.34
S_2 : 45 cm	45.99	46.31	46.15	37.83	38.58	38.20	49.74	50.50	50.12	10.87	11.32	11.09
S_3 : 60 cm	46.34	46.83	46.58	38.72	39.35	39.03	51.27	51.98	51.62	11.73	12.30	12.02
S.Em±	0.12	0.06	0.04	0.29	0.23	0.13	0.14	0.12	0.10	0.07	0.03	0.04
C.D. (P=0.05)	0.48	0.25	0.17	1.13	0.92	0.50	0.54	0.46	0.40	0.27	0.12	0.18
Fertilizer levels (F)												
F_1 : 100:40:40	45.02	45.34	45.18	36.56	37.19	36.87	47.00	47.54	47.27	10.64	11.08	10.86
F_2 : 100:60:40	45.22	45.54	45.38	36.87	37.59	37.23	47.62	48.31	47.97	10.69	11.31	11.00
F_3 : 150:40:40	46.72	47.05	46.89	38.80	39.63	39.22	51.78	52.40	52.09	11.09	11.52	11.31
F_4 : 150:60:40	46.87	47.31	47.09	39.21	40.01	39.61	52.24	53.04	52.64	11.22	11.66	11.44
S.Em±	0.32	0.22	0.16	0.48	0.44	0.32	0.12	0.14	0.10	0.06	0.03	0.03
C.D. (P=0.05)	0.95	0.65	0.47	1.42	1.31	0.95	0.35	0.42	0.28	0.17	0.09	0.10
Interactions (S x F)												
S.Em±	0.50	0.34	0.24	0.77	0.70	0.50	0.22	0.24	0.17	0.11	0.06	0.07
C.D. (P=0.05)	NS**	NS	NS	NS	NS	NS	0.74	0.77	0.58	0.37	0.18	0.22

*DAS: Days after sowing **NS: Non significant

Table 4. Effect of inter row spacing and fertilizer levels on seed yield per plant, seed yield per hectare and dry fodder yield per hectare of CoFS-29

Treatment	Seed yield per plant (g)			Seed yield per hectare (kg)			Dry fodder yield per hectare (q)		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Inter row spacing (S)									
S_1 : 30 cm	11.55	12.23	11.89	634.4	680.8	657.6	122.8	130.7	126.7
S_2 : 45 cm	13.33	14.02	13.68	579.6	641.0	610.3	115.2	126.2	120.7
S_3 : 60 cm	14.96	15.61	15.29	504.5	573.0	538.8	109.7	119.7	114.7
S.Em±	0.05	0.07	0.06	5.8	6.7	6.2	1.0	0.9	0.7
C.D. (P=0.05)	0.20	0.26	0.22	22.8	26.3	24.2	4.1	3.7	2.8
Fertilizer levels (F)									
F_1 : 100:40:40	12.59	13.18	12.88	534.8	593.1	564.0	111.6	120.8	116.2
F_2 : 100:60:40	13.11	13.81	13.46	552.7	612.4	582.5	112.7	123.0	117.9
F_3 : 150:40:40	13.57	14.27	13.92	592.2	649.3	620.7	118.6	127.8	123.2
F_4 : 150:60:40	13.86	14.56	14.21	611.6	671.6	641.6	120.7	130.5	125.6
S.Em±	0.04	0.07	0.05	7.4	8.4	7.4	1.3	1.0	0.7
C.D. (P=0.05)	0.12	0.20	0.15	21.9	24.9	21.9	4.0	3.0	2.2
Interactions (S x F)									
S.Em±	0.08	0.12	0.10	12.5	14.2	12.7	2.3	1.8	1.3
C.D. (P=0.05)	0.27	0.39	0.32	39.7	45.3	40.5	NS*	NS	NS

*NS: Non significant

attributed to its increased availability of essential nutrients to the plants favoring higher crop growth and flowering parameters, as reported earlier (Pathan and Kamble, 2014). Obviously, it might result in higher production, translocation and accumulation of photosynthates into the developing sinks from the photosynthetic sources. These results were in agreement with those of Patel *et al.* (2007) in oat and Singh *et al.* (2008) in maize.

Influence of spacing and fertilizer levels on seed quality parameters: Seed quality parameters like 1000 seed weight, seed germination percentage and seedling vigour index were significantly higher in 60 cm (6.57 g, 40.83 % and 1120, respectively) as against 30 and 45 cm row spacing (Table 5). The superior seed quality parameters in terms of germination and vigour index noticed in the wider spacing might be ascribed to the better source to sink relationship causing in efficient accumulation and assimilation of photosynthates into sinks from source in view of better growth and reproductive parameters as against narrow inter row spacing. The similar trend of superior seed quality parameters under wider row spacing were also reported earlier in buffel grass (Kumar *et al*., 2005), forage maize (Singh *et al*., 2008) and rye grass (Simic *et al*., 2010). The similar trend on seed yield and quality components was also observed in 2013-14 and 2014-15.

Similarly, application 150:60:40 kg NPK ha^{-1} registered significantly higher 1000 seed weight (6.52 g), seed germination (40.22%) and vigour index (1096) as compared to 100:40:40 NPK kg per hectare (6.2 g, 37.17% and 971, respectively) (Table 5). The significant increase in the seed quality parameters seen in the higher fertilizer level might be due to the increased application of essential nutrients and it enhanced the synthesis and transportation of photosynthates into the sinks and increased the seed size and thus resulted in higher seed quality as against those grown at lower fertilizer level. Similar results were observed in fodder maize (Singh *et al.,* 2008).

Further interaction effect between inter row spacing and fertilizer levels were found to be non-significant for growth and quality parameters in pooled data and during individual years of study. Further, seed yield and dry fodder yield per hectare was significantly higher in the treatment combination of 30 cm row spacing and 150:60:40 kg NPK per hectare (671.0 kg and 131.9 q, respectively) and lower (462.8 kg and 109.7 q, respectively) in 60 cm row spacing and 100:40:40 kg NPK per hectare (Table 4). Similar results were also reported in buffel grass (Sharma *et al*., 2002; Kumar *et al*., 2005) and sweet corn (Narayanaswamy and Siddaraju, 2011).

Table 5. Effect of inter row spacing and fertilizer levels on 1000 seed weight, seed germination and seedling vigour of cv. CoFS-29

Treatment	Seed yield per plant (g)			Seed yield per hectare (kg)			Dry fodder yield per hectare (q)		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
Inter row spacing (S)									
S_1 : 30 cm	6.04	6.09	6.06	35.58	36.17	35.88	902	934	918
S_2 : 45 cm	6.42	6.46	6.44	39.00	39.67	39.33	1042	1075	1058
S_3 : 60 cm	6.56	6.59	6.57	40.67	41.00	40.83	1104	1136	1120
S.Em±	0.03	0.03	0.03	0.29	0.32	0.28	6	12	9
C.D. (P=0.05)	0.12	0.11	0.11	1.16	1.24	1.11	25	48	36
Fertilizer levels (F)									
F_1 : 100:40:40	6.18	6.22	6.20	36.89	37.44	37.17	955	987	971
F_2 : 100:60:40	6.24	6.28	6.26	37.56	38.11	37.83	982	1011	996
F_3 : 150:40:40	6.43	6.47	6.45	39.33	39.67	39.50	1051	1080	1065
F_4 : 150:60:40	6.50	6.54	6.52	39.89	40.56	40.22	1076	1115	1096
S.Em±	0.02	0.02	0.02	0.44	0.30	0.34	13	10	10
C.D. (P=0.05)	0.06	0.05	0.06	1.30	0.88	1.00	40	28	31
Interactions (S x F)									
S.Em±	0.04	0.04	0.04	0.72	0.55	0.58	21	19	18
C.D. (P=0.05)	0.15	0.13	0.14	NS*	NS	NS	NS	NS	NS

*NS: Non significant

Conclusion

It was concluded that application of higher fertilizer level i.e. 150:60:40 NPK kg/ha with inter row spacing of 30 cm was more effective in getting higher seed yield and dry fodder yield without affecting much on seed quality as compared to other treatments.

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